

Appropriate Lighting Technologies for the Poorest Mountain Communities in the Nepal Himalayas

Alex Zahnd

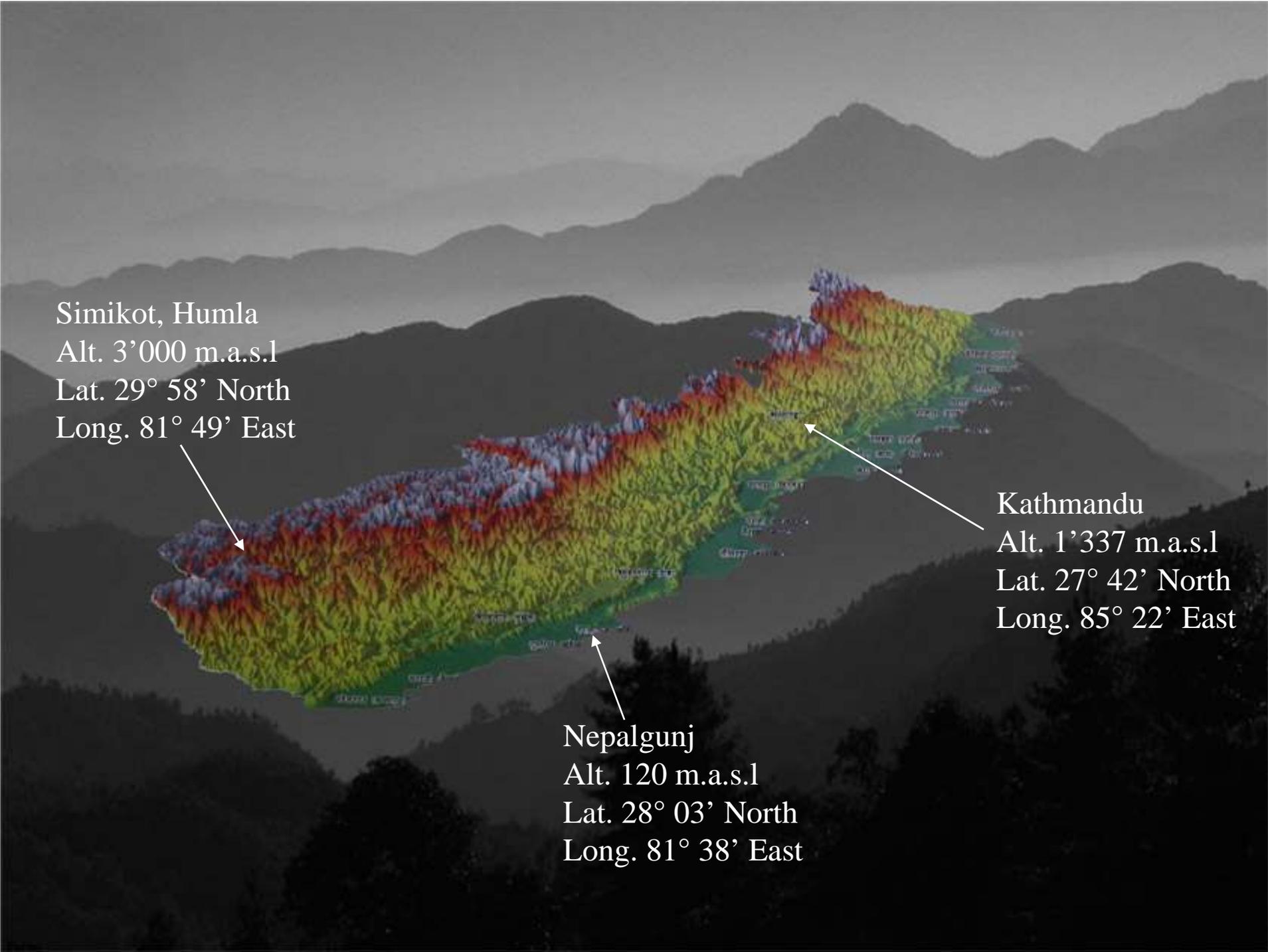
Kathmandu University

NEPAL





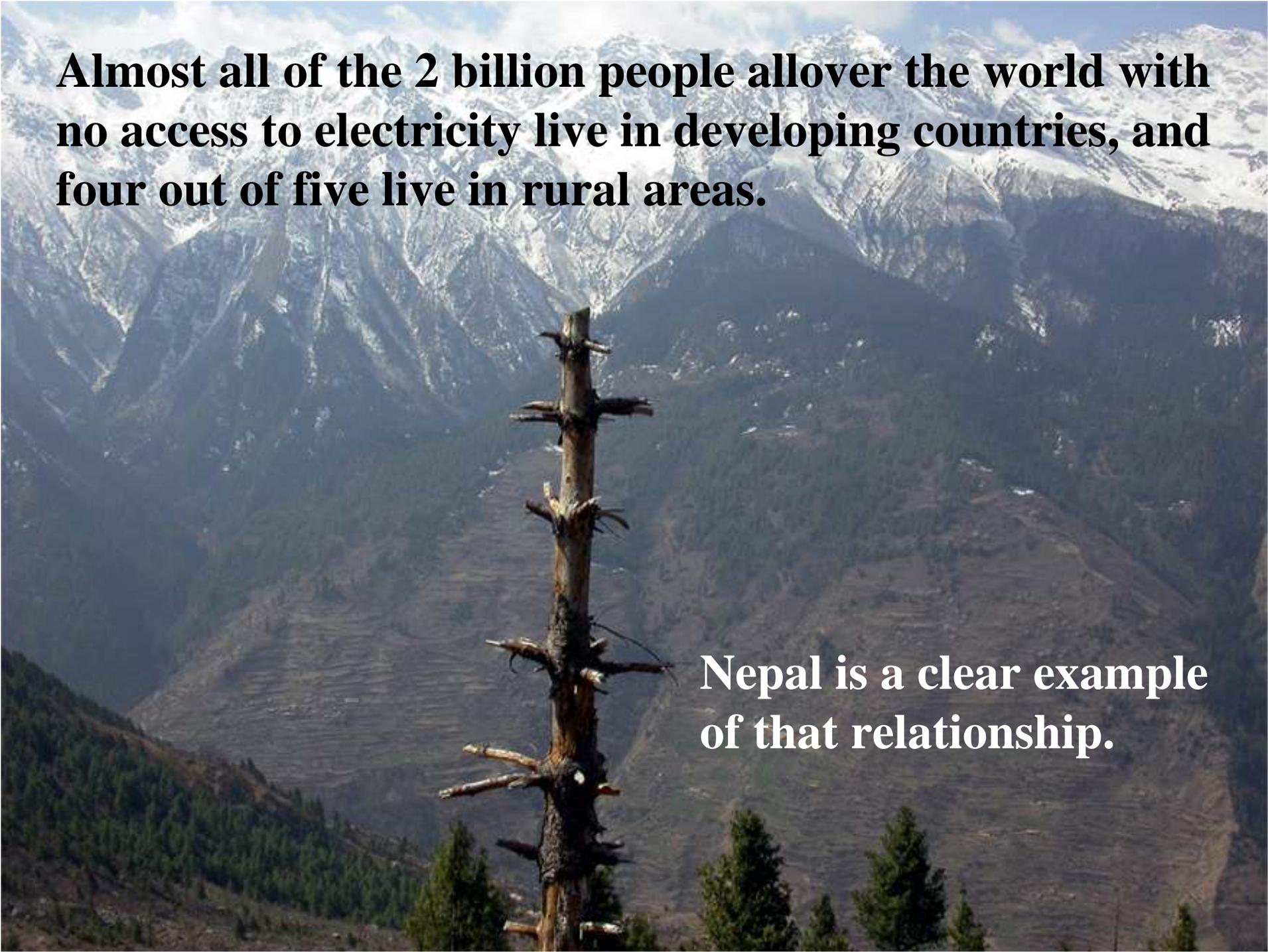




Simikot, Humla
Alt. 3'000 m.a.s.l
Lat. 29° 58' North
Long. 81° 49' East

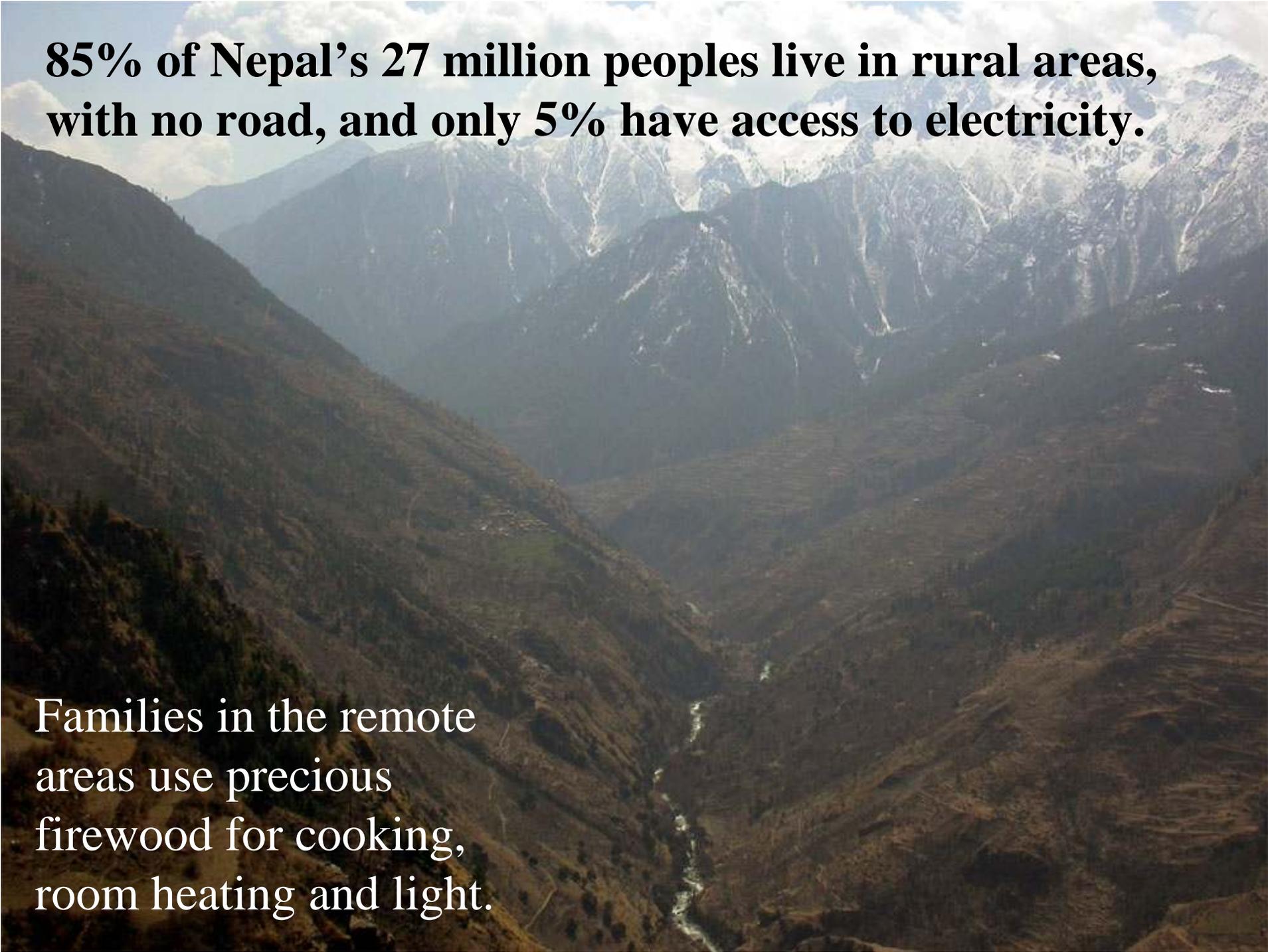
Kathmandu
Alt. 1'337 m.a.s.l
Lat. 27° 42' North
Long. 85° 22' East

Nepalgunj
Alt. 120 m.a.s.l
Lat. 28° 03' North
Long. 81° 38' East



Almost all of the 2 billion people all over the world with no access to electricity live in developing countries, and four out of five live in rural areas.

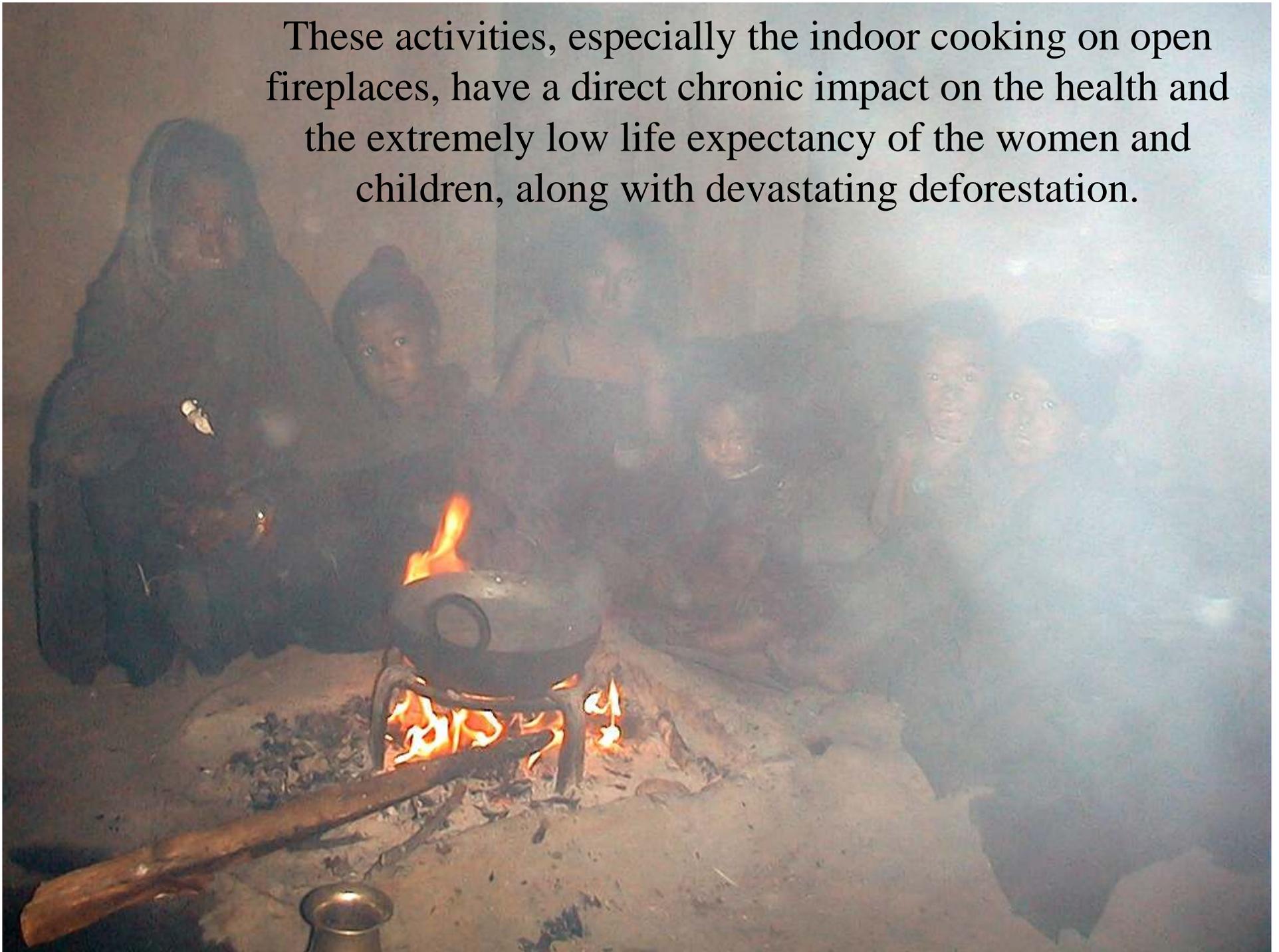
Nepal is a clear example of that relationship.



85% of Nepal's 27 million peoples live in rural areas, with no road, and only 5% have access to electricity.

Families in the remote areas use precious firewood for cooking, room heating and light.

These activities, especially the indoor cooking on open fireplaces, have a direct chronic impact on the health and the extremely low life expectancy of the women and children, along with devastating deforestation.



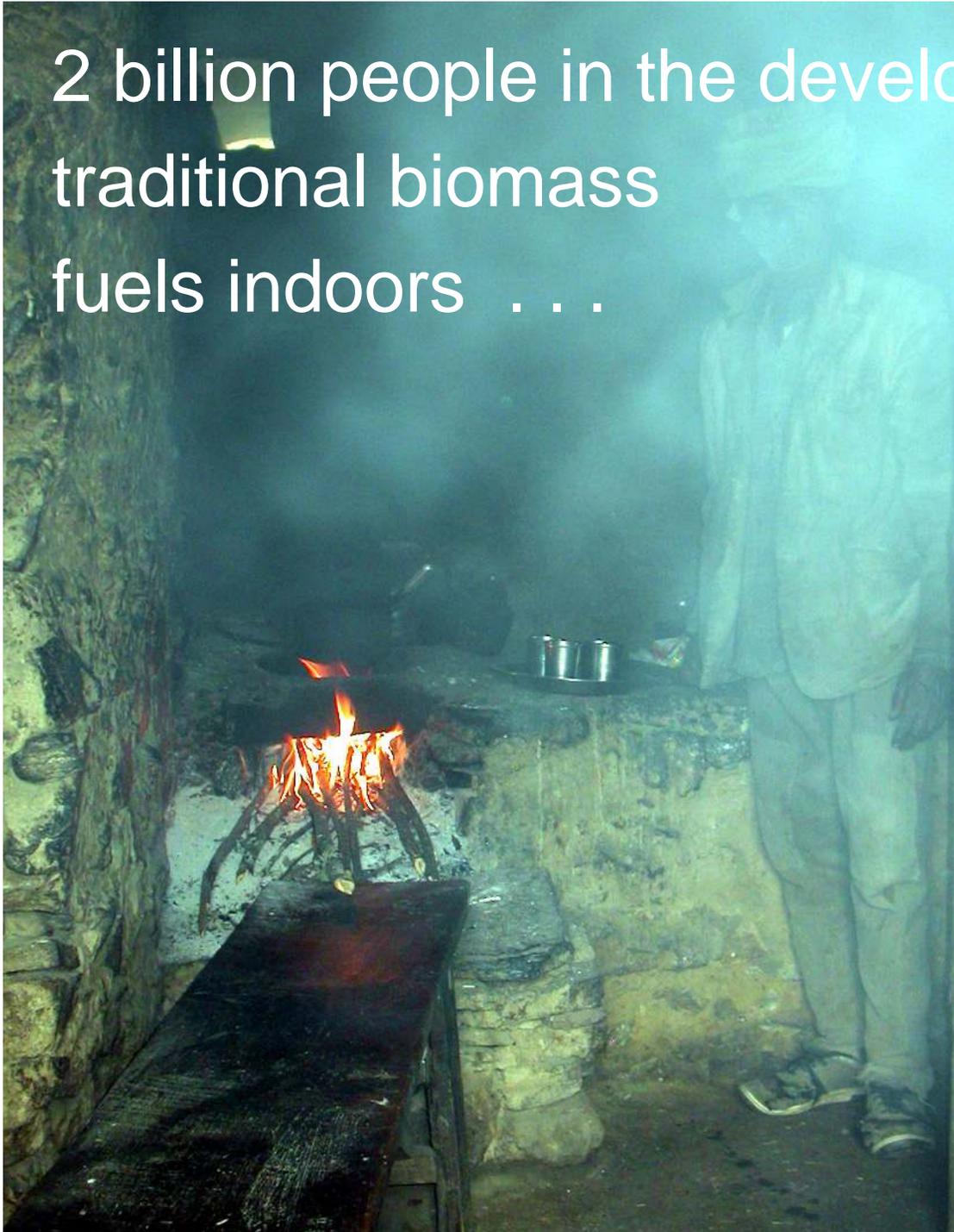
“Indoor pollution kills one person every 20 second in the developing countries”

Smoke – The Killer in the Kitchen, ITDG

In the high altitude remote mountain places of Humla in Nepal, the people are using tree resin lamps, called “jharro”, for night lighting.



2 billion people in the developing world burn traditional biomass fuels indoors . . .





. . . to fulfill their daily basic energy needs for cooking, heating and light.

Energy flows in a well-operating traditional wood-fired cooking stove in India.

Nominal Combustion

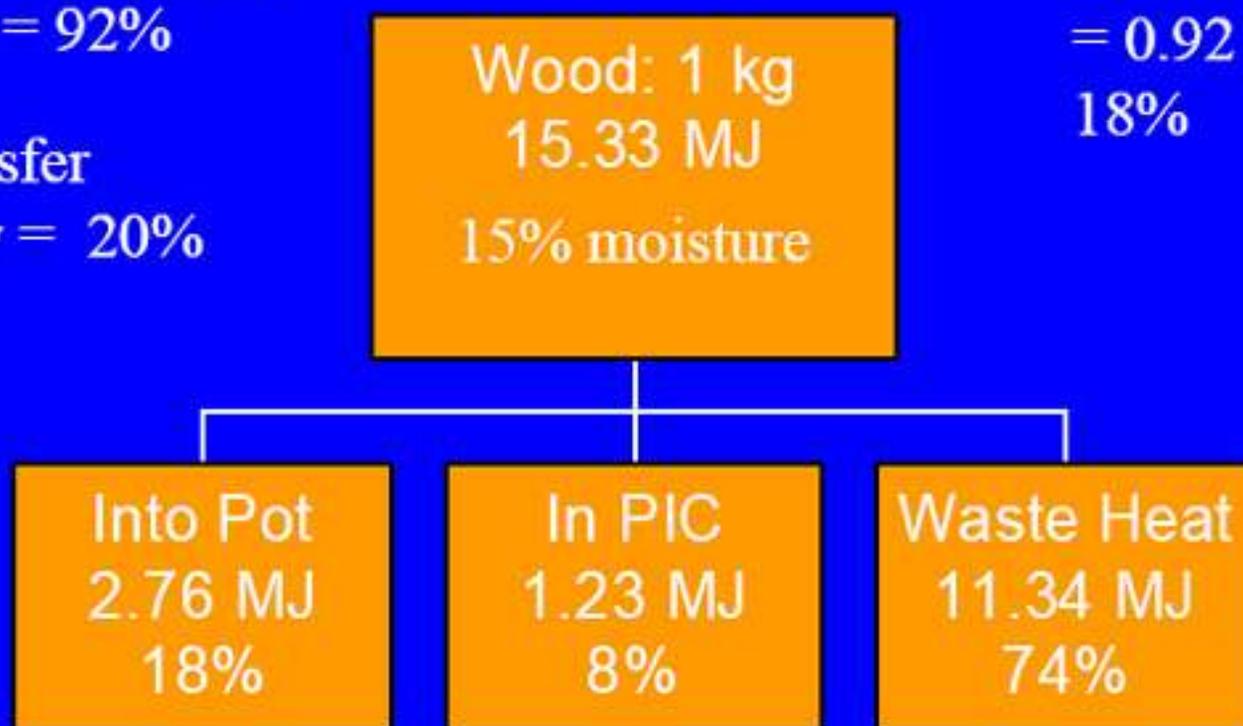
Efficiency = 92%

Heat Transfer

Efficiency = 20%

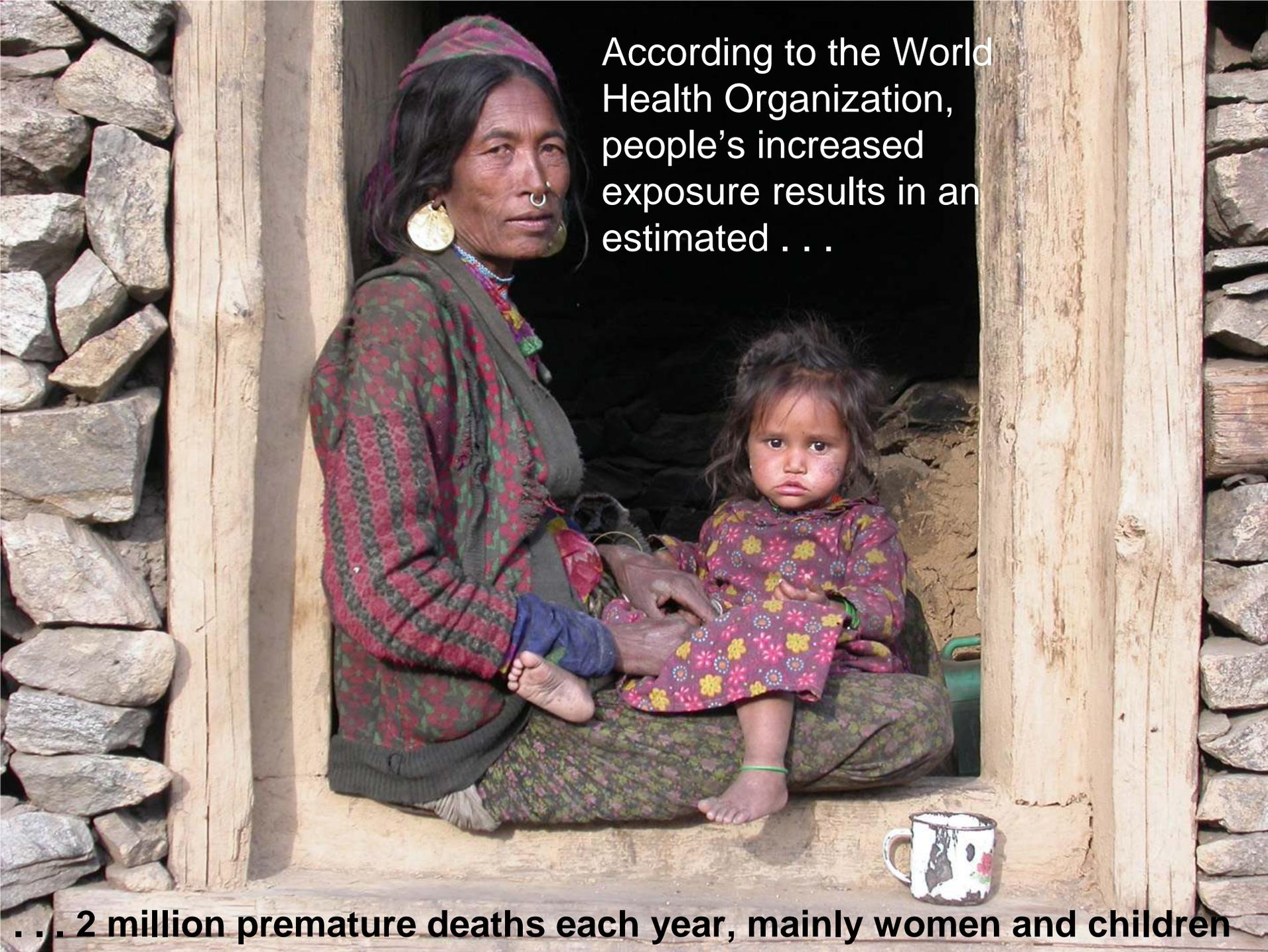
Total efficiency

= $0.92 \times 0.2 =$
18%



PIC = products of incomplete combustion = CO, HC, C, etc.

Source:
Smith,
et al.,
2000

A photograph of an elderly woman and a young child sitting in the doorway of a rustic stone and wood building. The woman is wearing a colorful patterned sweater and a headscarf, and has a nose ring. The child is wearing a floral dress. A small white mug with a floral design sits on the ground in front of them. The background is dark, suggesting the interior of the building.

According to the World Health Organization, people's increased exposure results in an estimated . . .

. . . 2 million premature deaths each year, mainly women and children



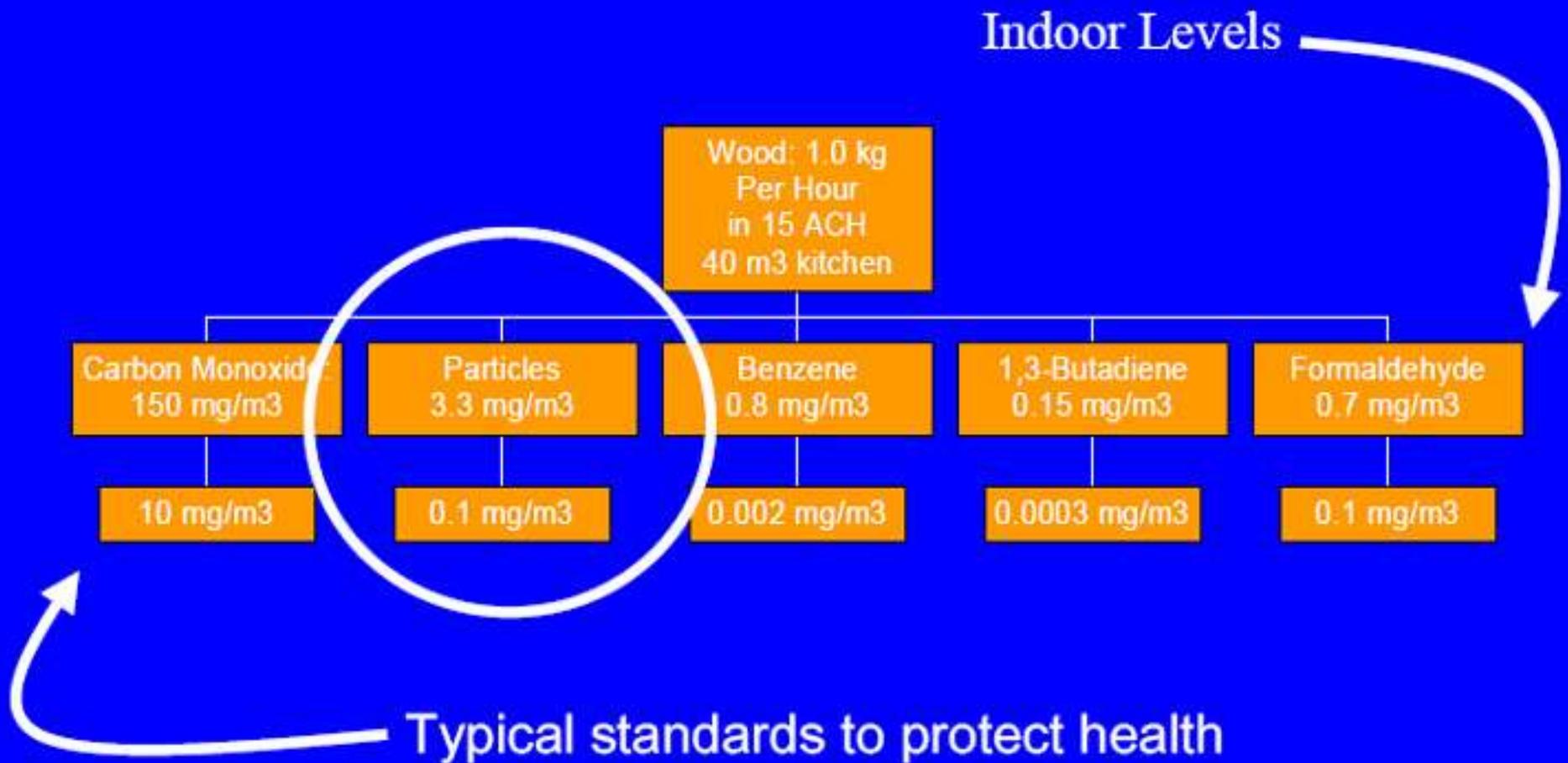
In order to understand the actual indoor pollution the women in particular are exposed, we started to measure the PM_{10} and TSP values inside the homes

We measured in different homes beside the PM_{10} and TSP values also the CO , CO_2 and O_2 values around the open fire places



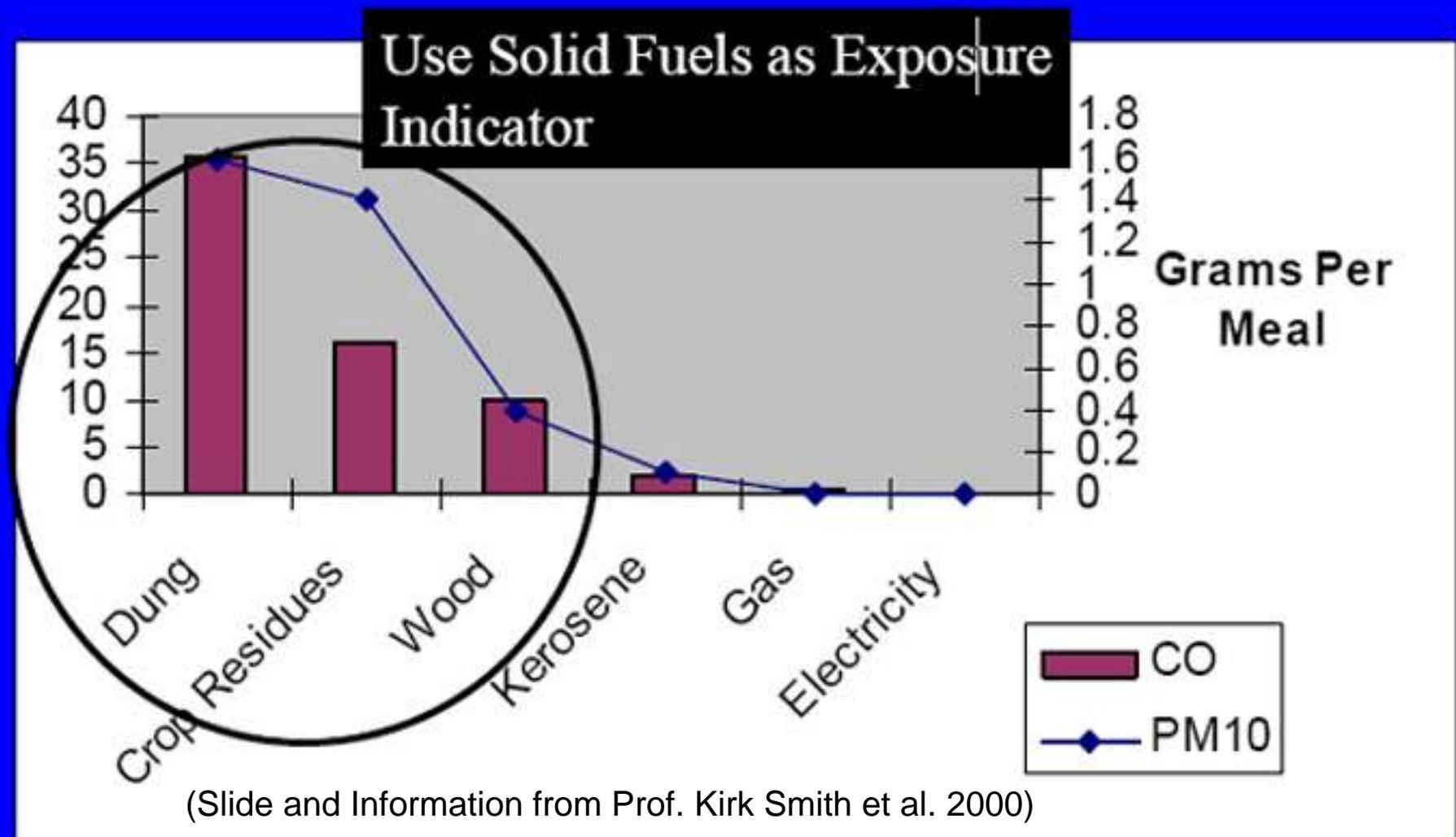
Indoor pollution concentrations from typical woodfired cookstove

Many dozen others are also known to be in woodsmoke.

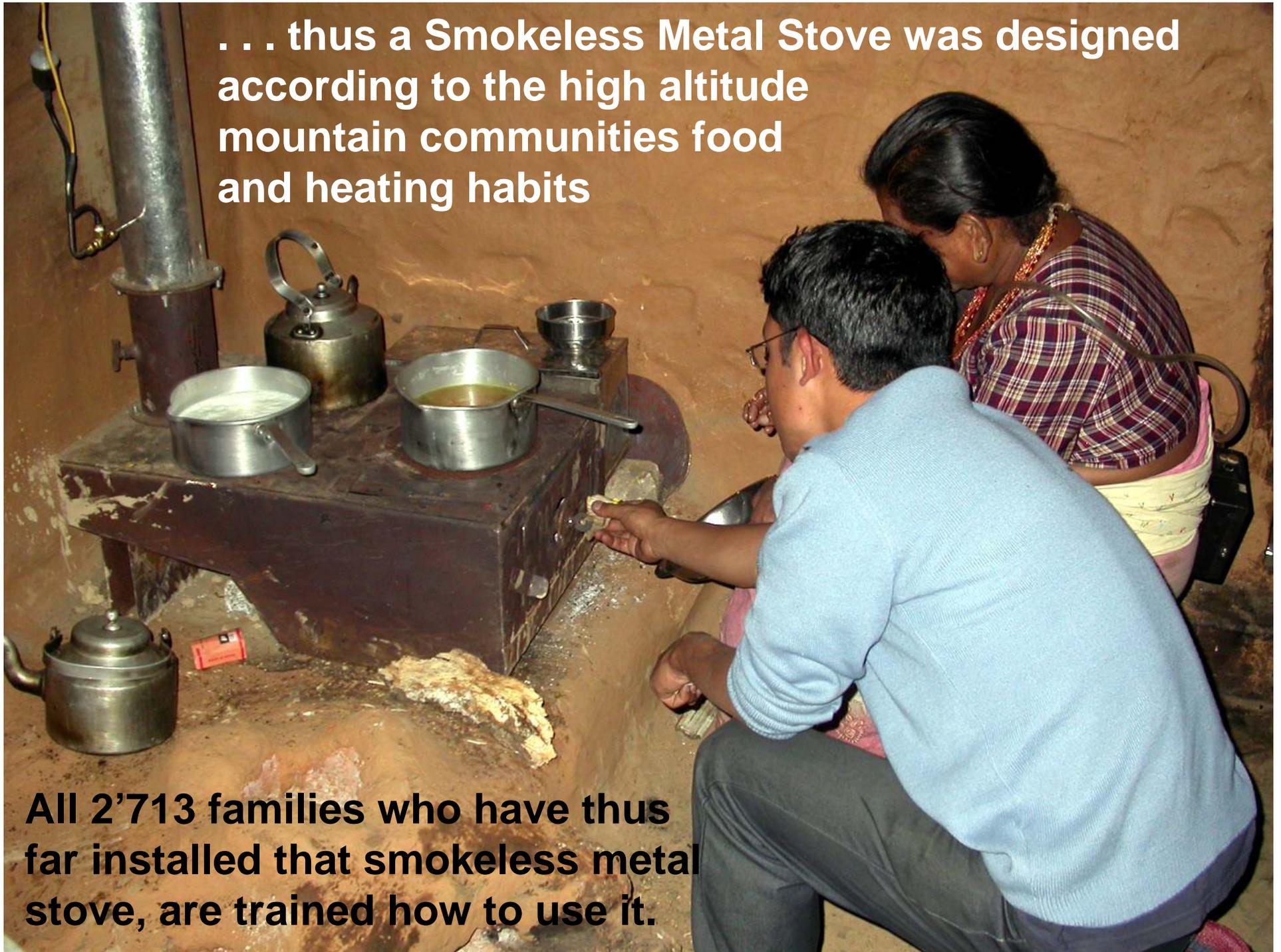


(Slide and Information from Prof. Kirk Smith et al. 2000)

Emissions Along the Household Energy Ladder



. . . thus a Smokeless Metal Stove was designed according to the high altitude mountain communities food and heating habits

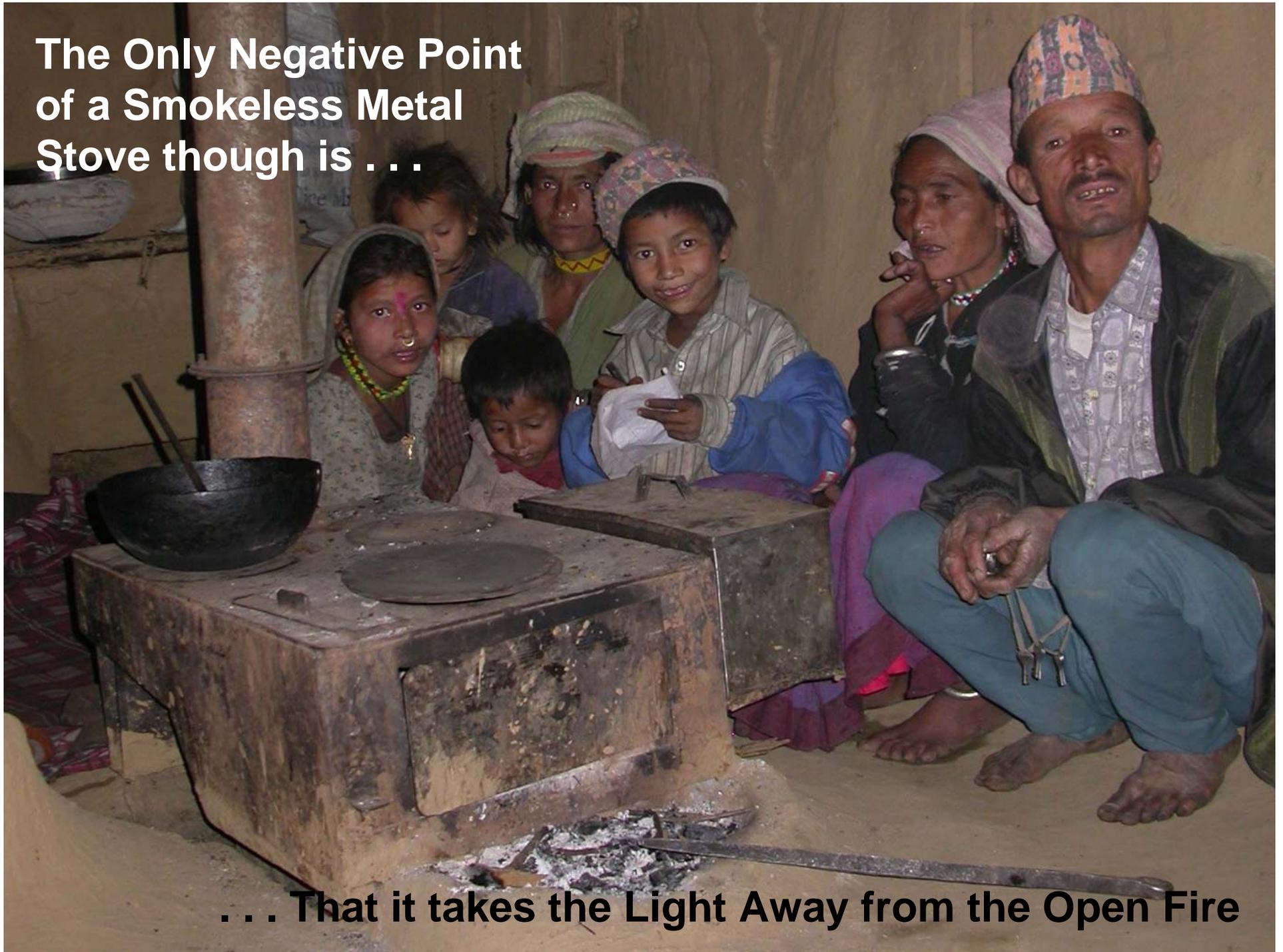


All 2'713 families who have thus far installed that smokeless metal stove, are trained how to use it.

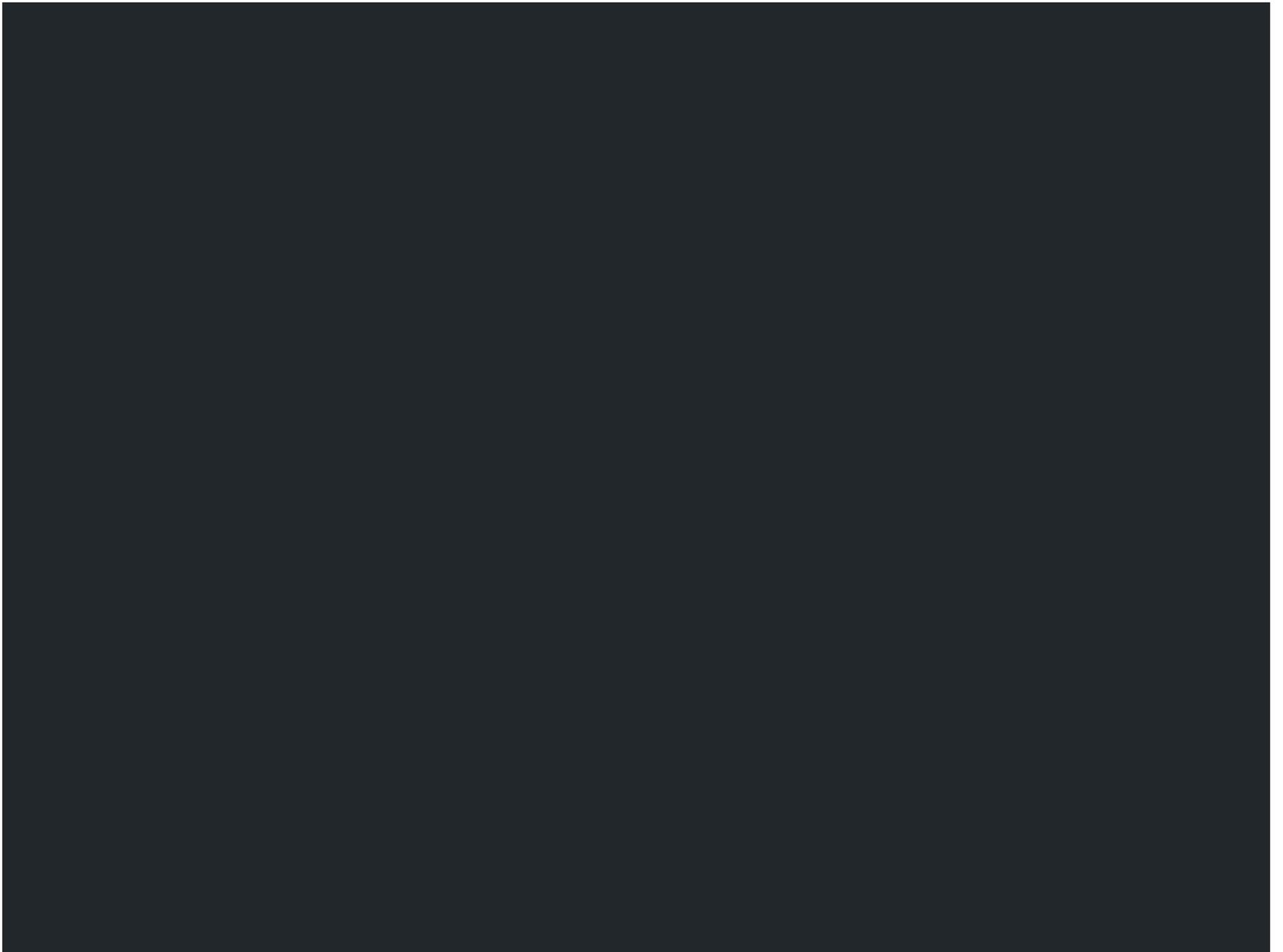
. . . and now cooking with clean indoor air and up to half the firewood saved is a great relief for the women



**The Only Negative Point
of a Smokeless Metal
Stove though is . . .**



. . . That it takes the Light Away from the Open Fire



. . . thus while a Smokeless Metal Stove is a good start to get rid of the smoke, still “jharro” is needed to have a dim light in the kitchen . . .

A photograph of a woman and four children in a rustic kitchen. The woman, wearing a blue headscarf and a patterned top, sits behind a large, built-in wood-burning stove. A fire burns in the stove's opening, and a large metal pot sits on top. Four children are gathered around the stove, looking towards the camera. The kitchen has wooden walls and shelves with various metal dishes and pots. The lighting is dim, primarily from the fire in the stove.

Are there appropriate and sustainable light solutions for these communities . . . ?



YES

Then I want to
know them too . . .

YES



An appropriate Light Solution needs to fulfill the Objective of . . .

1. Low Power Rating

This enables to provide more consumers through a small scale power generation systems, such as solar PV or Pico hydro power plants, cutting down the overall building and maintenance cost per household.

Hence the electricity is cheaper and thus more readily affordable.



**1 W
WLED**



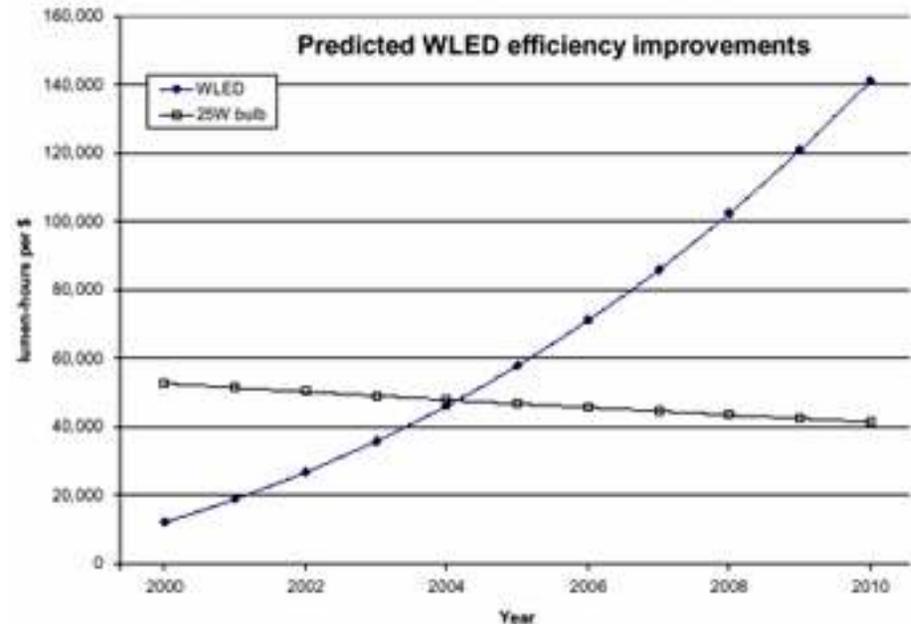
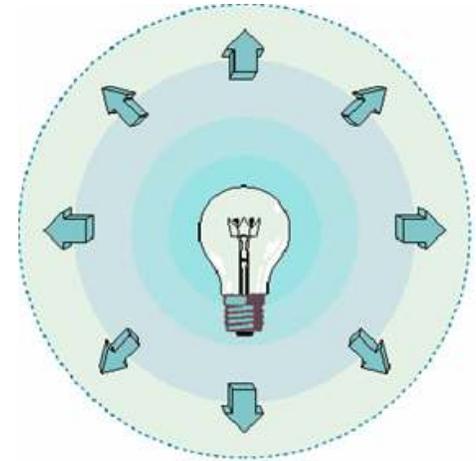
7W - 11 W CFL

An appropriate Light Solution needs to fulfill the Objective of . . .

2. High Efficiency

The Power Output / Power Input

ratio, has to be high. The “hotter” a light bulb is, the more inefficient it is. Incandescent bulbs have an efficiency of 4 – 6%. i.e., that a 60 W incandescent bulb generates ~ 57 W heat (in the infrared wave length) and ~ 3 Watt light (in visible wave length). A CFL light has ~ 30% efficiency, while WLED lights are rated between 25% - 80%.



An appropriate Light Solution needs to fulfill the Objective of . . .

3. High Power Factor

For AC lights a high power factor, i.e. ***Real Power/Apparent Power = > 0.9*** is aimed for, to limit the reactive power (i.e. the energy sloshing back and forth between the supply and the storage element in the device), which a consumer is NOT charged for if connected to the grid.

But for grid independent power systems such as a RAPS system it matters, as the Apparent Power (Reactive plus Real Power) has to be generated, BUT only the Real Power is converted into light.



An appropriate Light Solution needs
to fulfill the Objective of . . .

4. High Life Expectancy

A light can only be called
“appropriate” for a remote place if
its life expectancy can be
guaranteed for 5 - 7 years and
longer, and a daily use of of 4 - 6
hours.

That amounts to 8,000 – 15,000
hours guaranteed life expectancy
for a light.



An appropriate Light Solution
needs to fulfill the Objective of . . .



5. Affordable Price

A light must be affordable,
and it must be possible for
the consumer to purchase a
light under a defined
purchase / loan system.

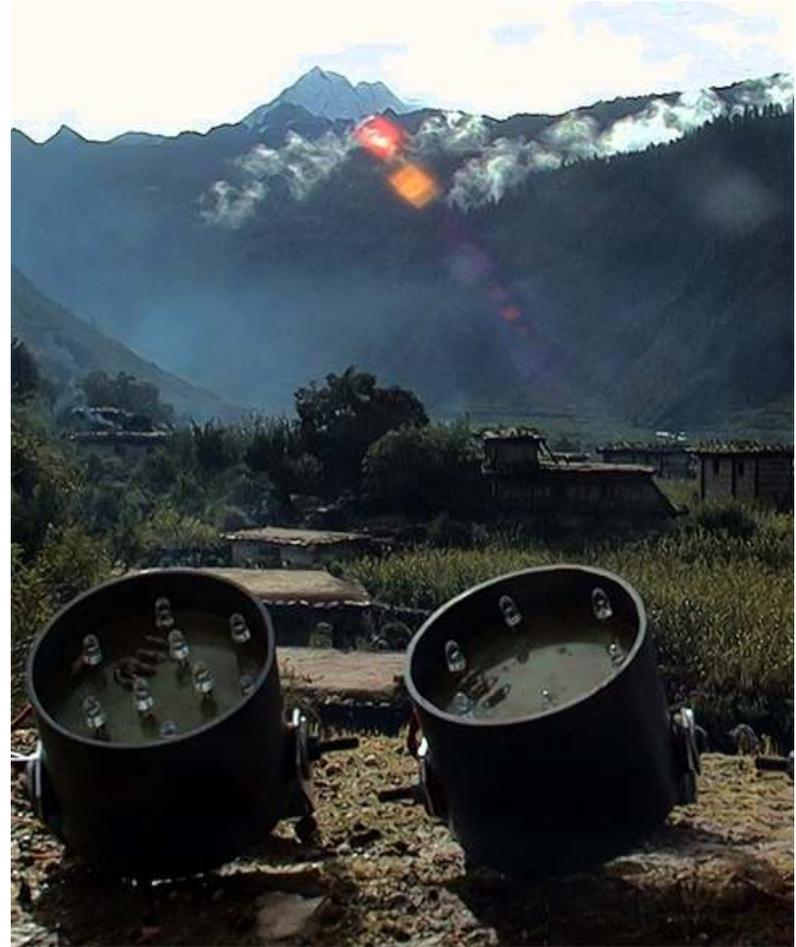


An appropriate Light Solution needs
to fulfill the Objective of . . .

6. Readily Available

A light has to be readily available in the local bazaar, or through an organised channel of provider.

Long journeys to unfamiliar places, such as cities or even Kathmandu the capital, to buy a new light, makes a light technology unsustainable.



An appropriate Light Solution needs to fulfill the Objective of . . .

7. Easy Maintenance

Lights get dirty, especially in remote mountain places where people burn wood, either openly or on stoves. In these conditions, the air always carries a higher level of pollutants / particles, making the lights quickly dirty. Thus periodical easy and quick cleaning of the lights and holders, without risk of damaging, is needed.



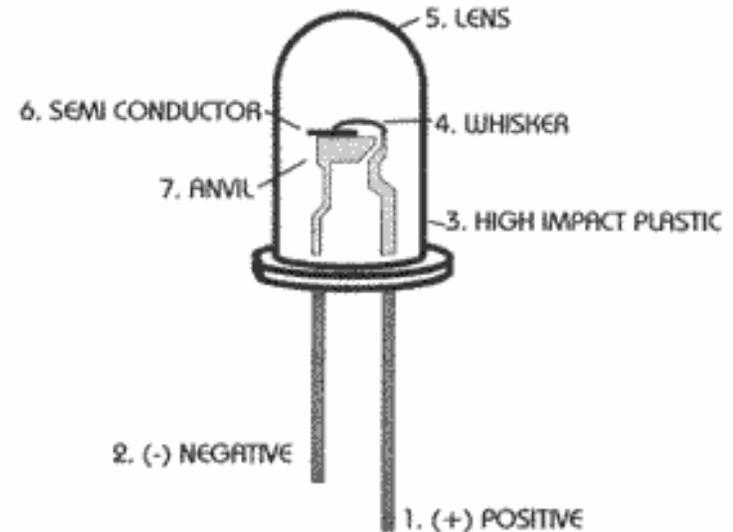
An appropriate Light Solution needs to fulfill the Objective of . . .

8. Not Easy to Break

With the remote mountain communities in view as main appliers of Pico hydro power plants and appropriate lights, the lights must be robust.

The life circumstances of these people groups are harsh and the climate is tough.

Thus lights need to be resistant to all these factors.



SSL (Solid State Lighting) in particular is very robust against all kinds of vibrations, rough handling and is virtually unbreakable, as the LED is fully cover in epoxy.

An appropriate Light Solution needs to fulfill the Objective of ...

9. High Lumen Output

It is the aim to have a high Lumen per Watt light output, as this is the actual “brightness”, or “light” the consumer perceives as useful light.

It MUST be BRIGHT enough to see each other and to be able to read, so that NO wood or kerosene is needed for light.



Lumileds’ Luxeon Efficiency Records in the Laboratory:

Red	50 lm/Watt
Red-Orange	65 lm/Watt
Amber	44 lm/Watt
Green	50 lm/Watt
Blue	15 lm/Watt
White	30 lm/Watt

Appropriate Light Solutions needs to fulfill the following Objectives of

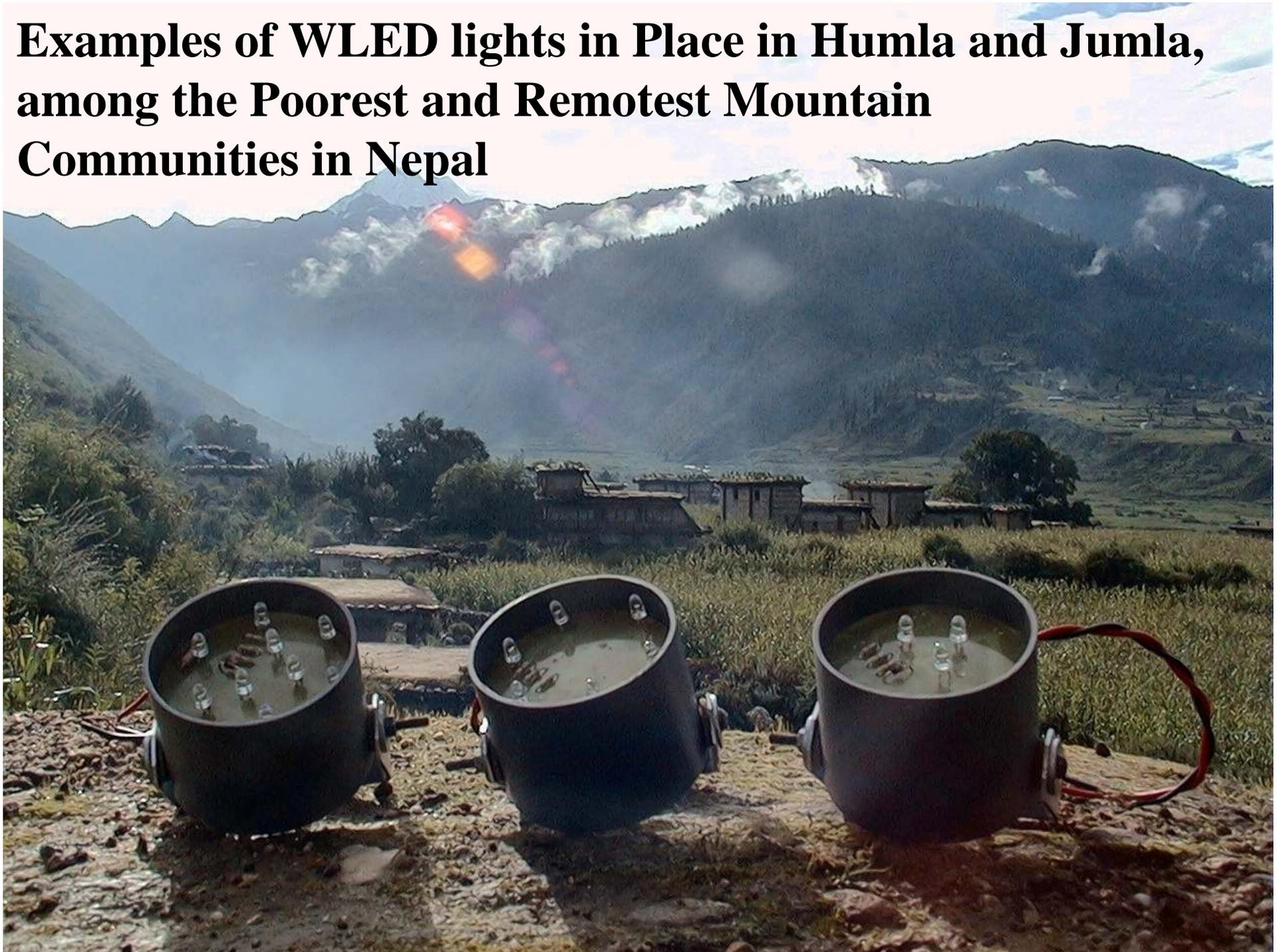


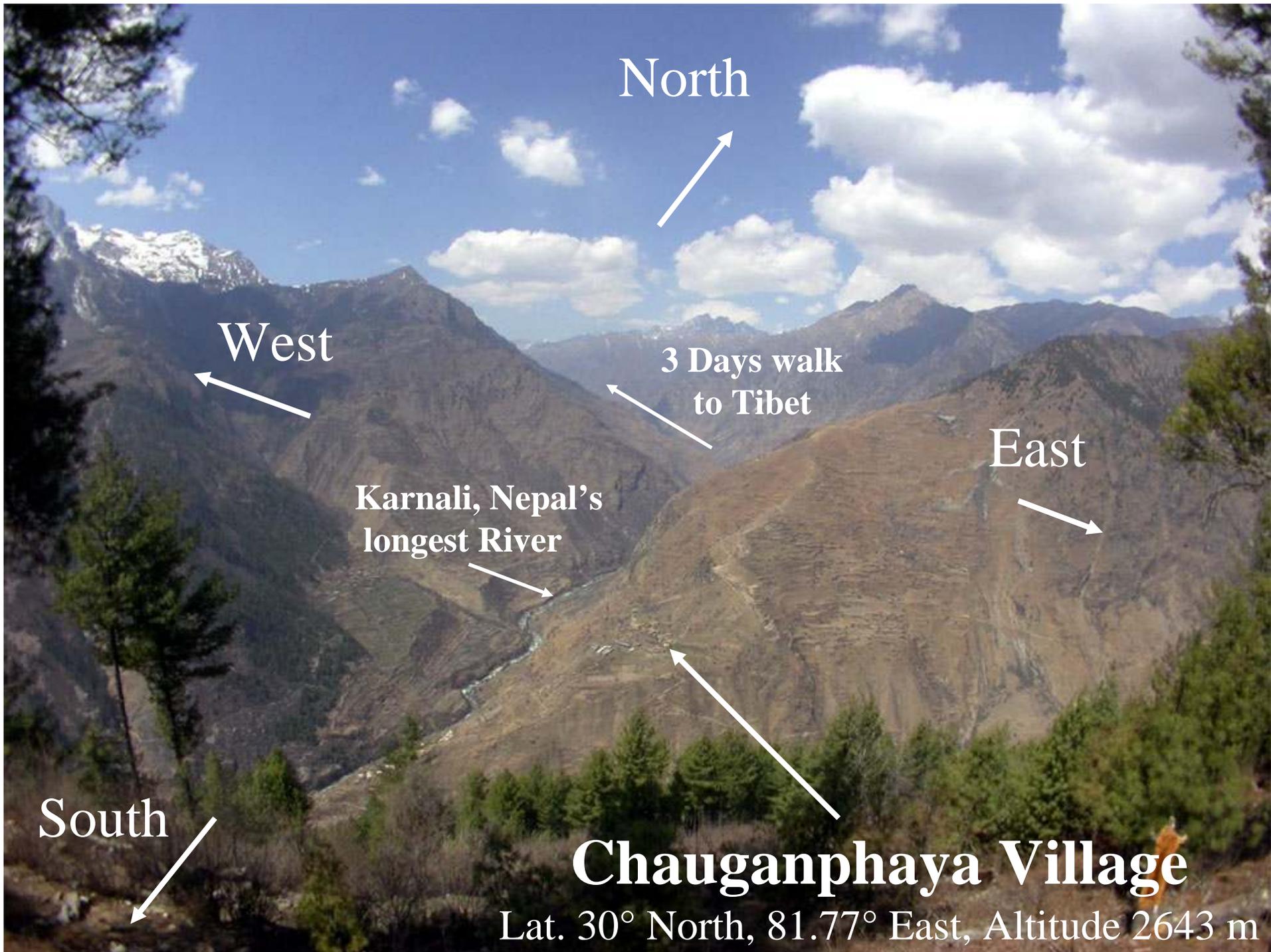
. . .

- 1. Low Power Rating***
- 2. High Efficiency***
- 3. High Power Factor***
- 4. High Life Expectancy***
- 5. Affordable Price***
- 6. Readily Available***
- 7. Easy to Maintain***
- 8. Not Easy to Break***
- 9. High Lumen Output***



Examples of WLED lights in Place in Humla and Jumla, among the Poorest and Remotest Mountain Communities in Nepal





North

West

3 Days walk
to Tibet

East

Karnali, Nepal's
longest River

South

Chauganphaya Village

Lat. 30° North, 81.77° East, Altitude 2643 m

Chauganphaya Village in Humla NEPAL

(Latitude 30° North, Longitude 81.77° East, Altitude 2643 m)

What is Needed ?

- Light
- Stove
- Pit Latrine
- Drinking Water

Village situation in 2003:

- 62 homes, and 365 peoples
- No house had light
- All homes cooked on open fires
- No home had a toilets
- All drank dirty river water



**With Solar
Energy Powered**



**1 Watt Power
Consumption**

**WLED (White Light
Emitting Diodes), with**



**75 Watt Solar
PV Module**

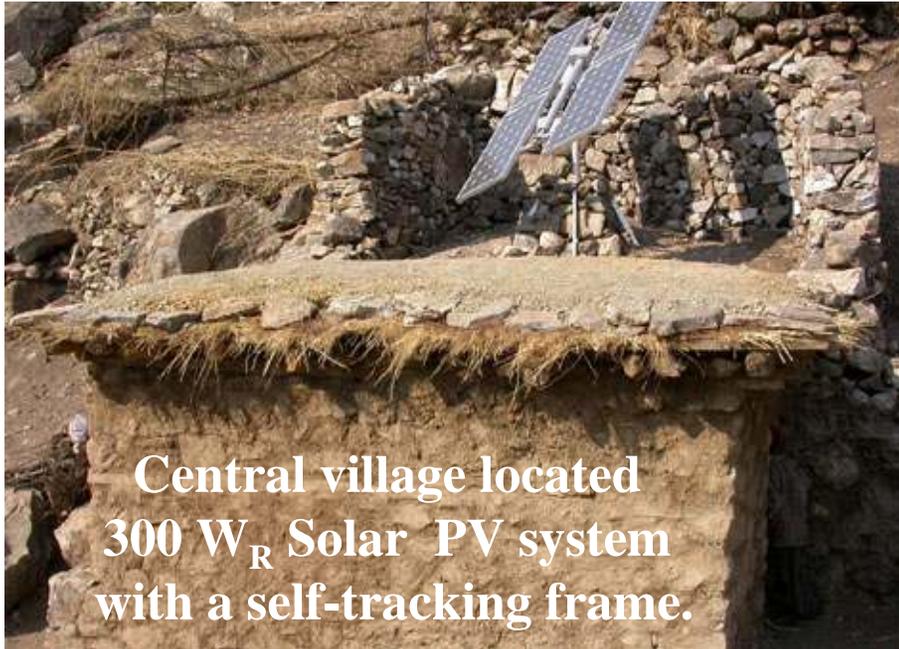


**For up to 20
Homes with 3
WLED Lights**

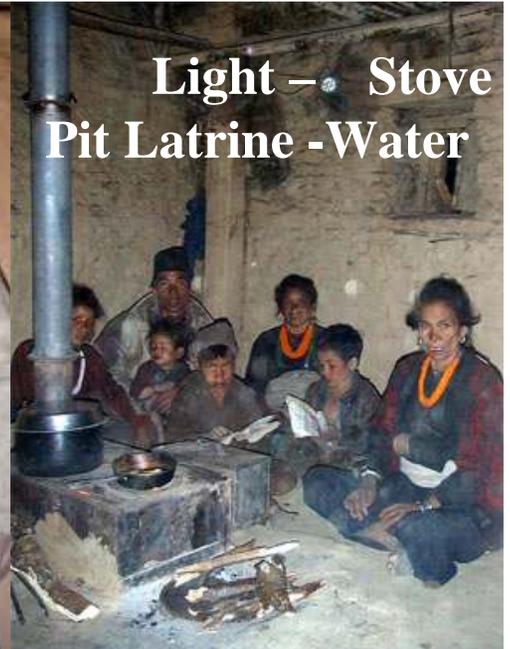




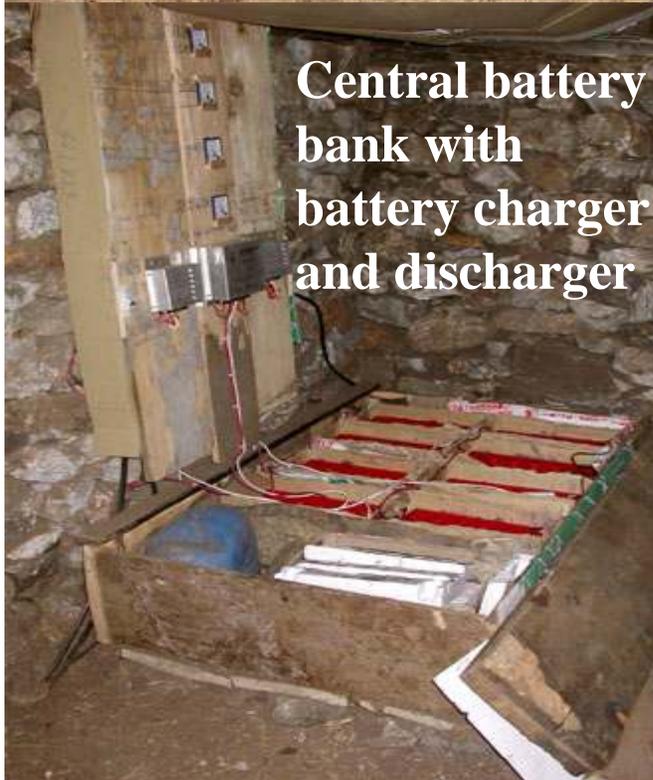




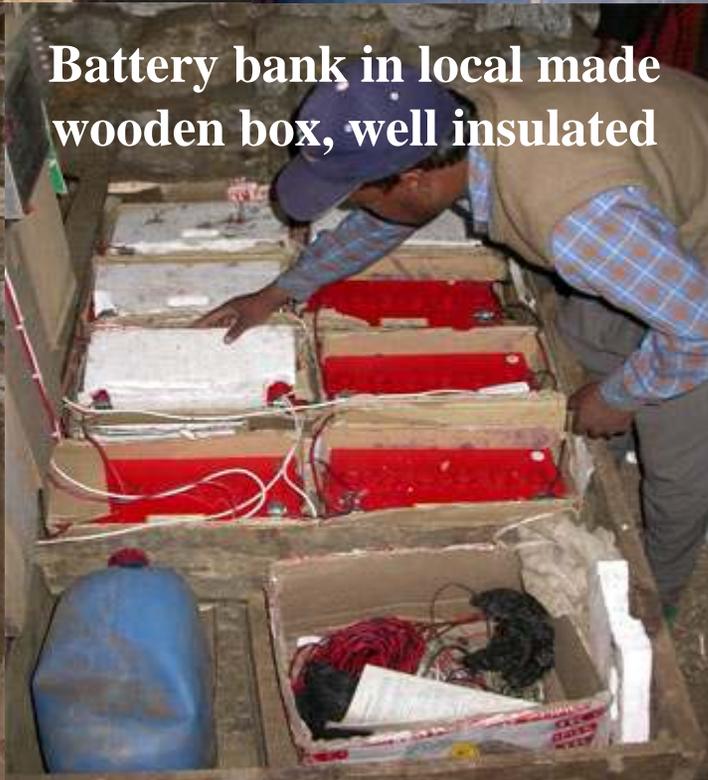
Central village located
300 W_R Solar PV system
with a self-tracking frame.



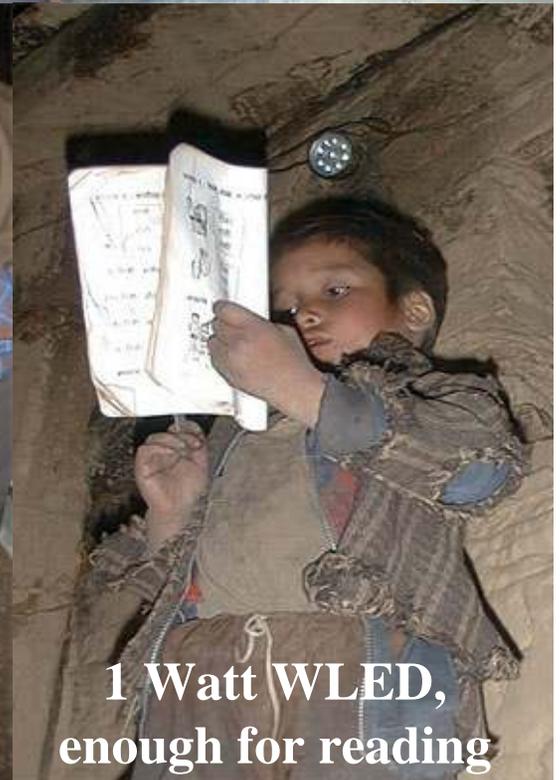
Light – Stove
Pit Latrine - Water



Central battery
bank with
battery charger
and discharger

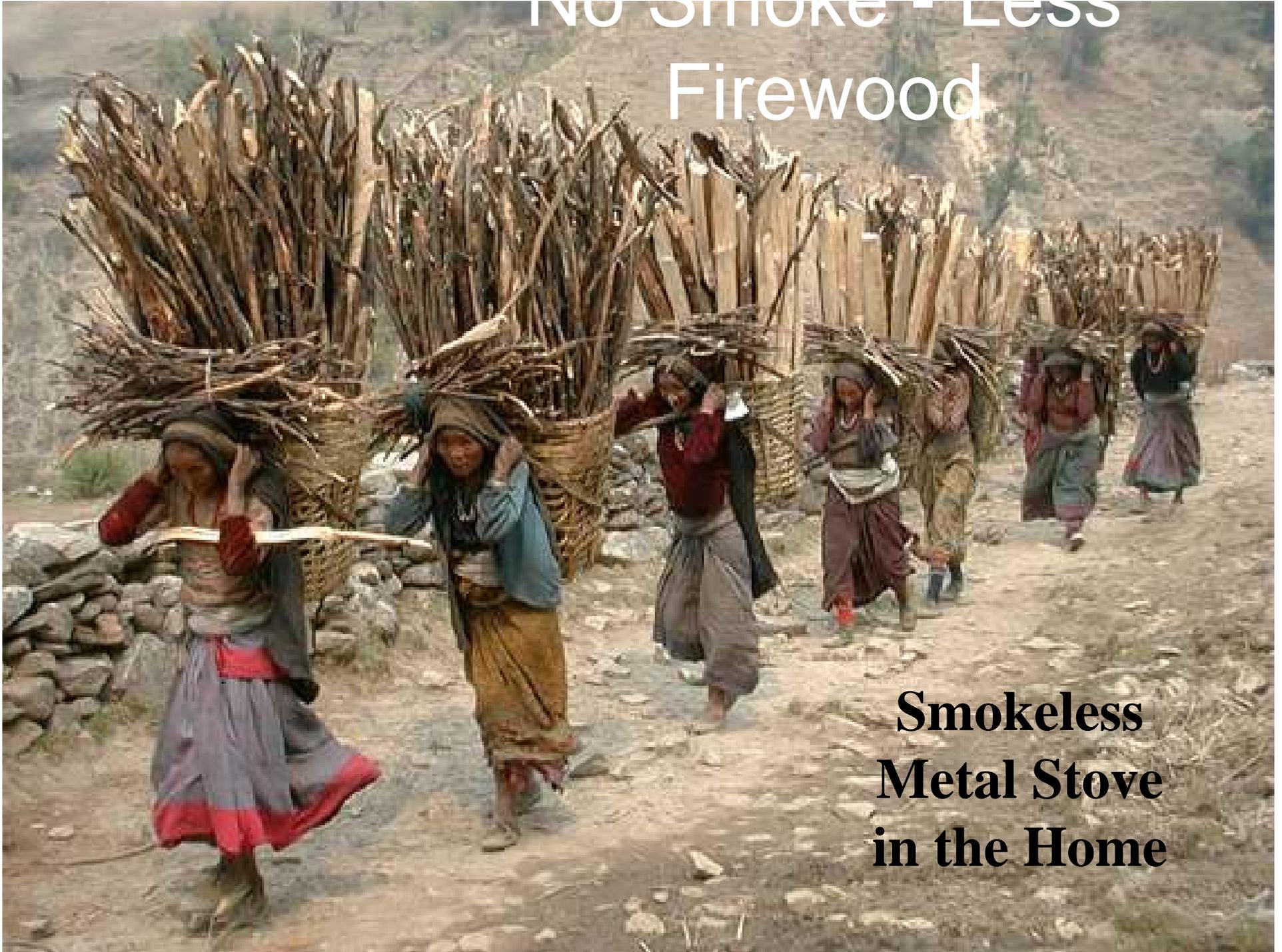


Battery bank in local made
wooden box, well insulated



1 Watt WLED,
enough for reading

NO SMOKE - LESS
Firewood



**Smokeless
Metal Stove
in the Home**

NO SMOKE - LESS

Firewood

Open Fire Place, the Homes Full of Smoke. The Daily Firewood Consumption is as high as 30 kg – 50 kg, and the Health of Women and Children is in great danger.

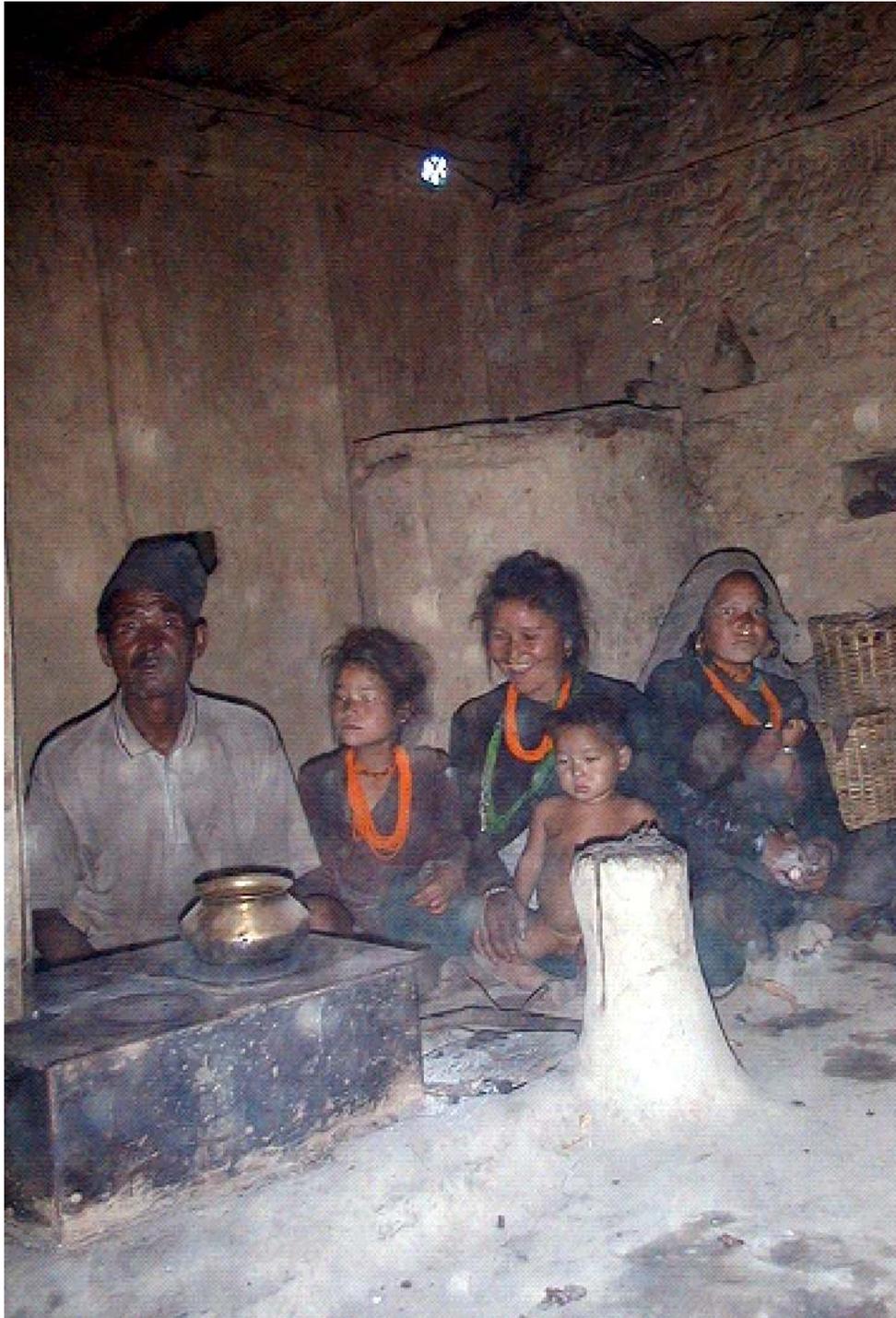


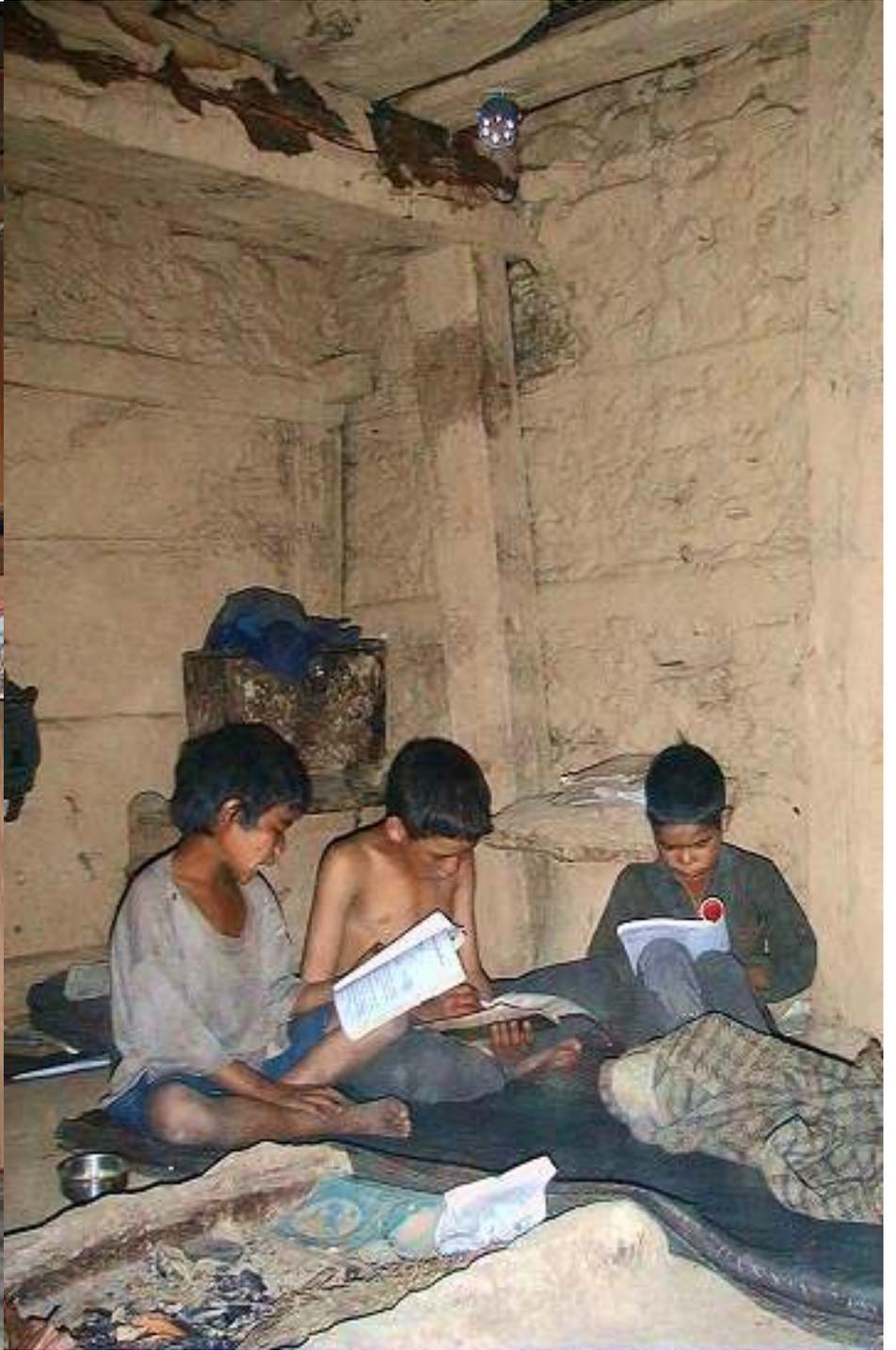
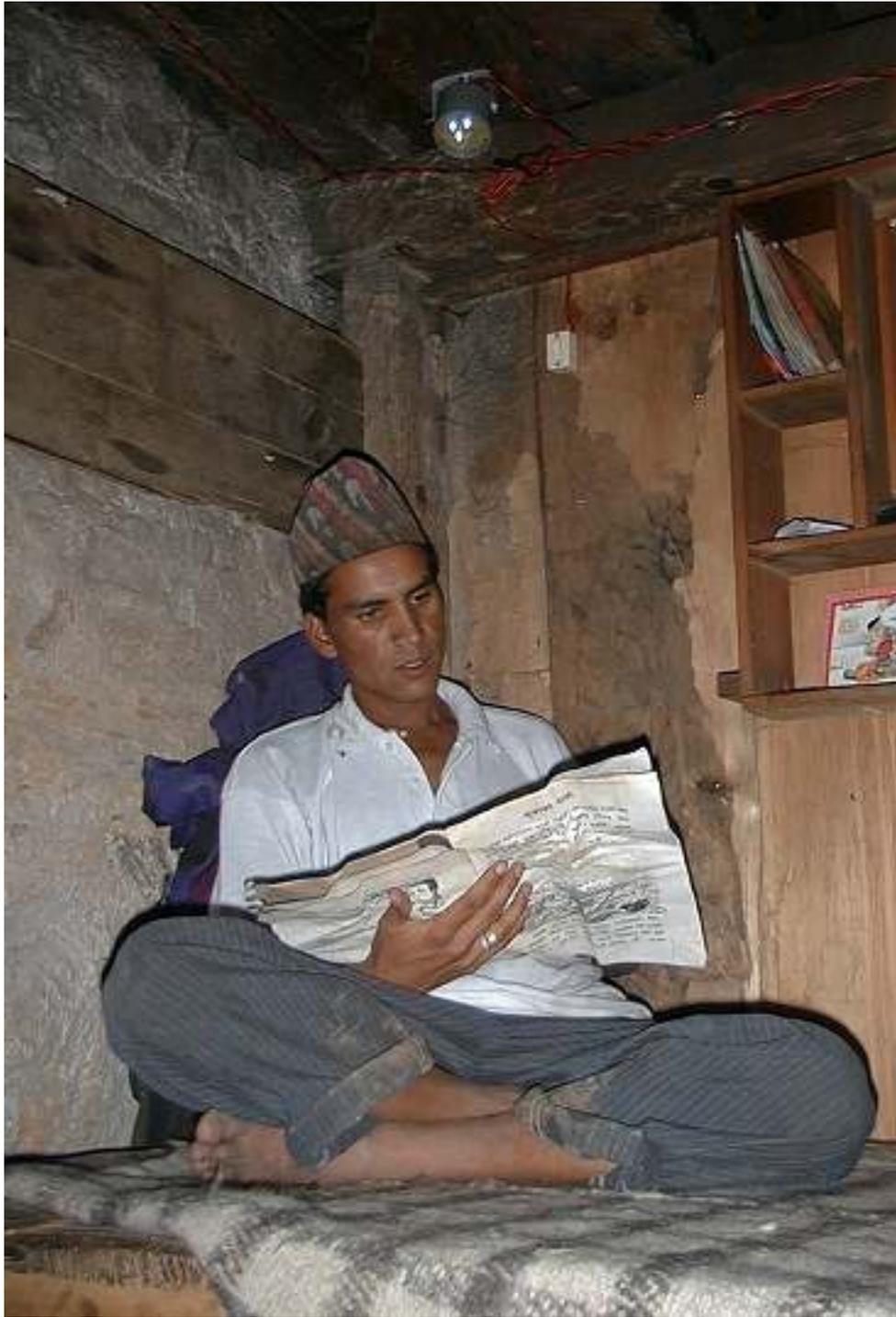
No Smoke - Less Firewood

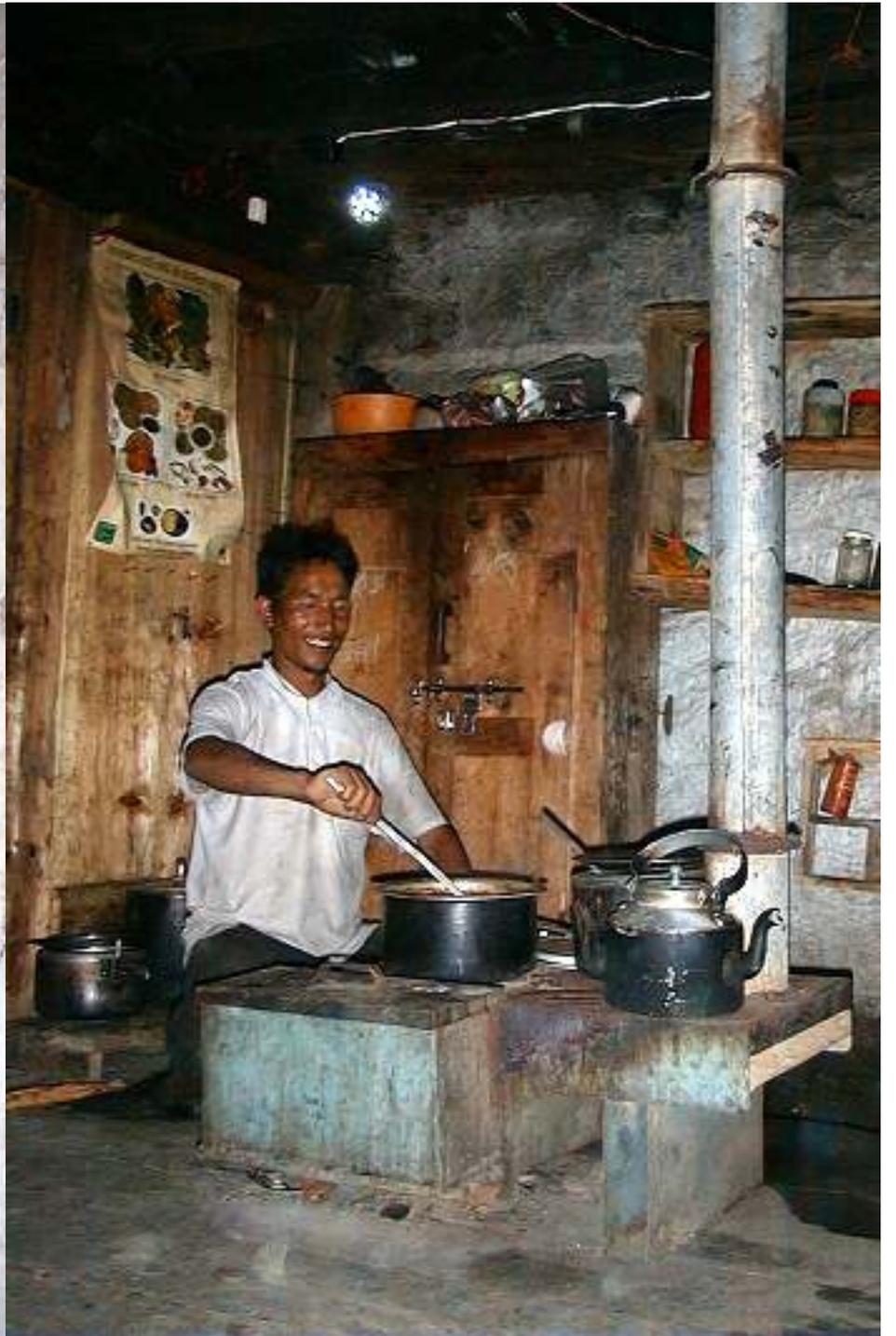
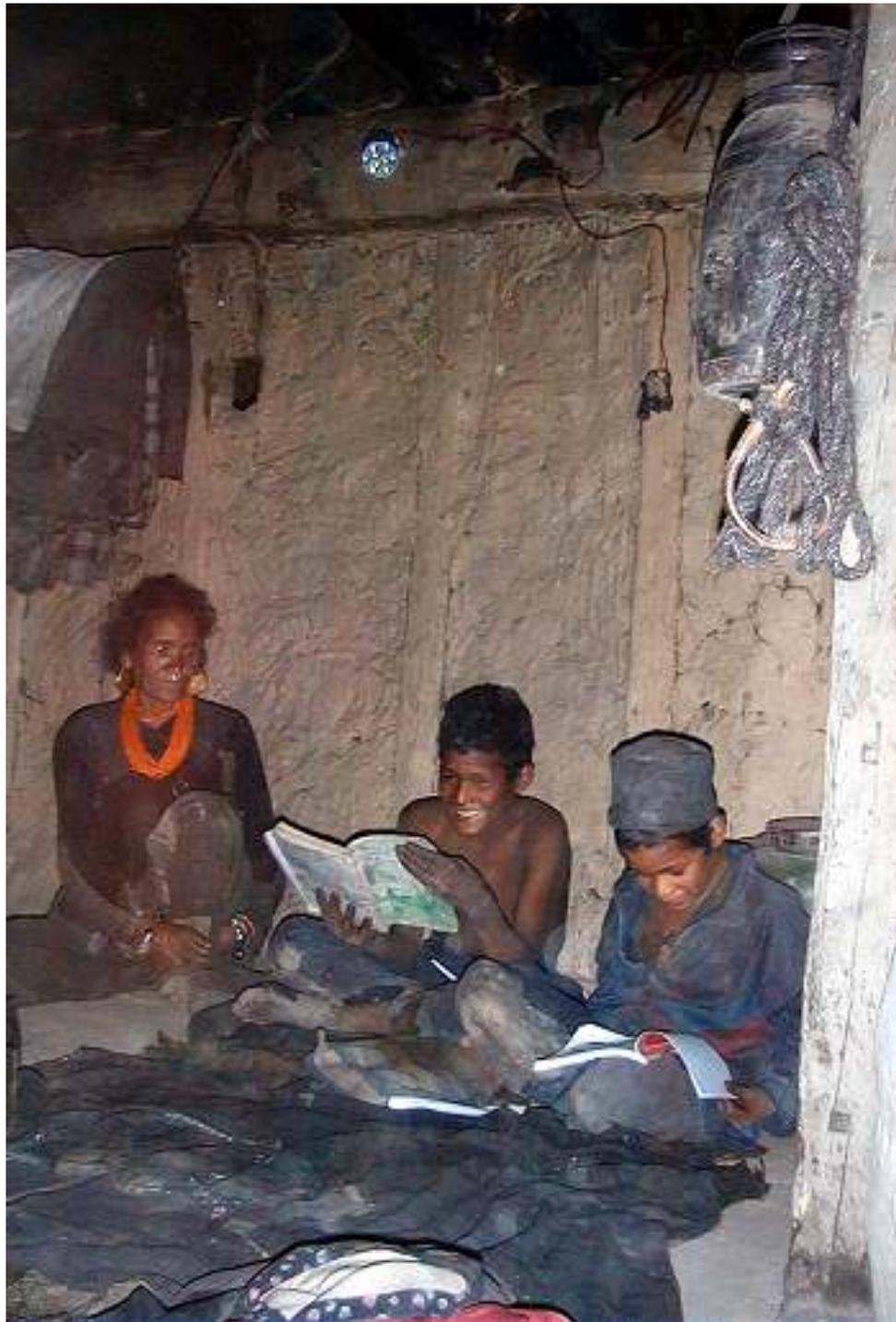
No Smoke inside Homes through a Smokeless Metal Stove. Daily 40% - 50% less Firewood Consumption. Great Improved Health Conditions.

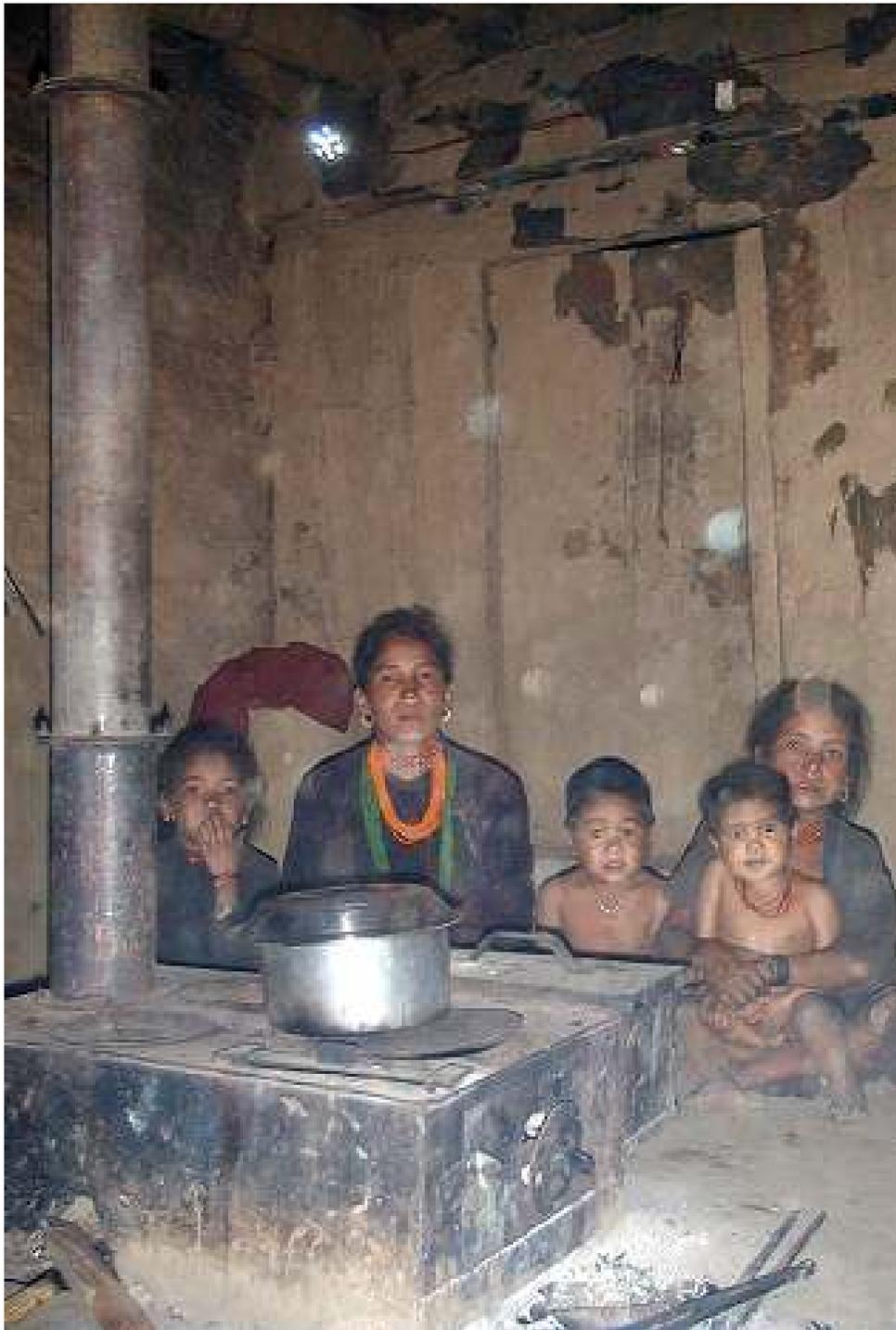
Open Fire Place, the Homes Full of Smoke. The Daily Firewood Consumption is as high as 30 kg – 50 kg, and the Health of Women and Children is in great danger.

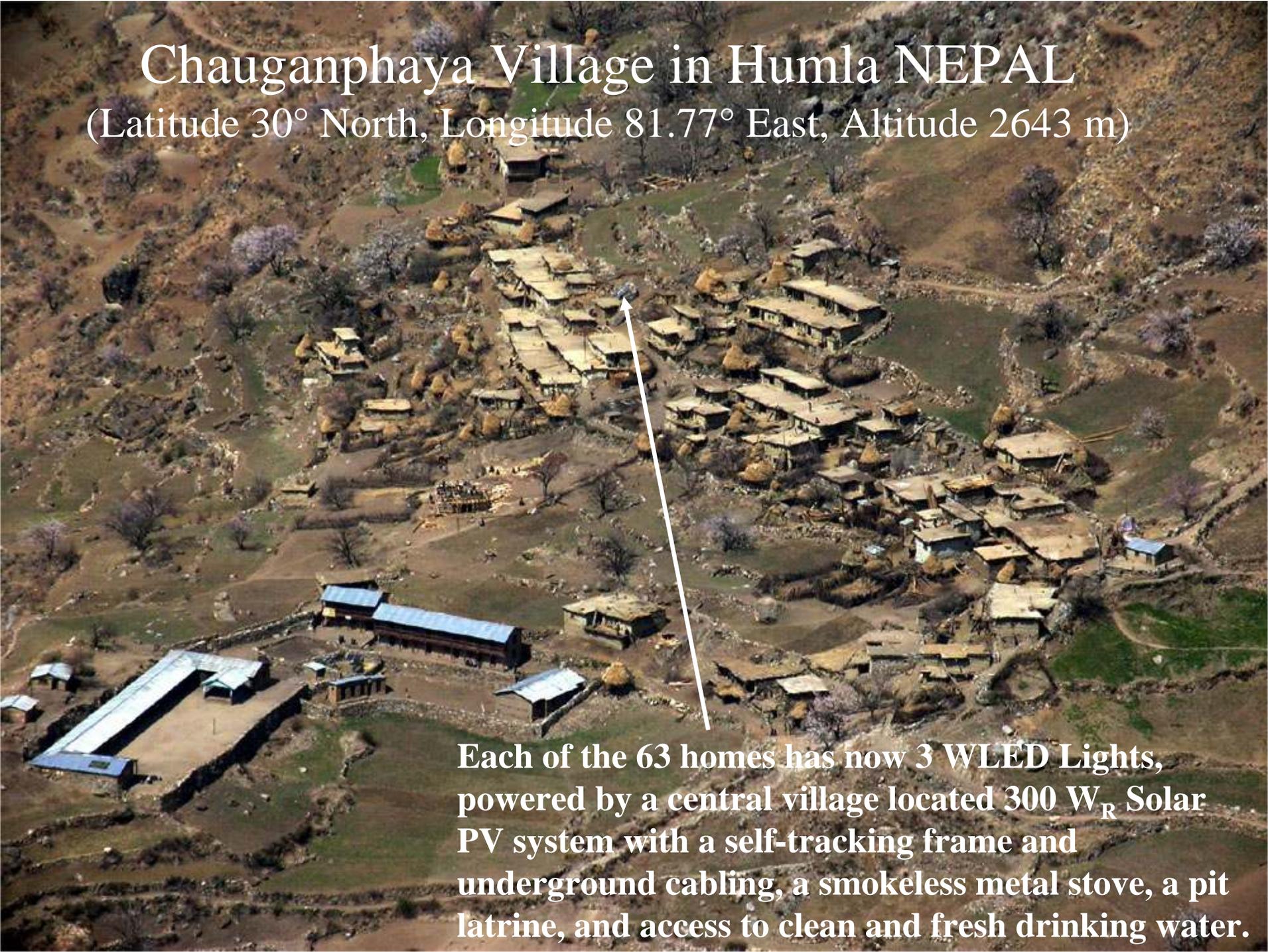












Chauganphaya Village in Humla NEPAL

(Latitude 30° North, Longitude 81.77° East, Altitude 2643 m)

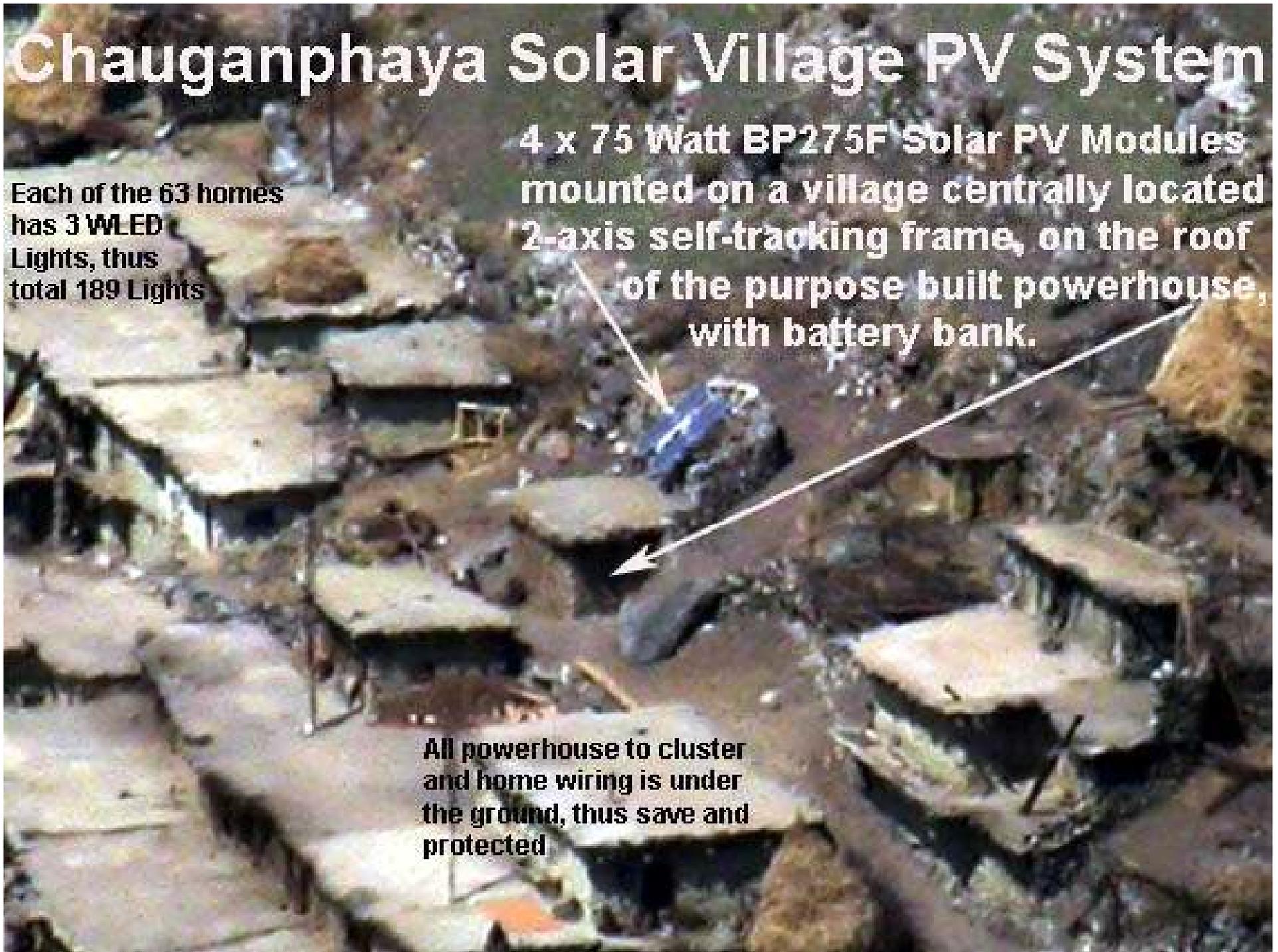
Each of the 63 homes has now 3 WLED Lights, powered by a central village located 300 W_R Solar PV system with a self-tracking frame and underground cabling, a smokeless metal stove, a pit latrine, and access to clean and fresh drinking water.

Chauganphaya Solar Village PV System

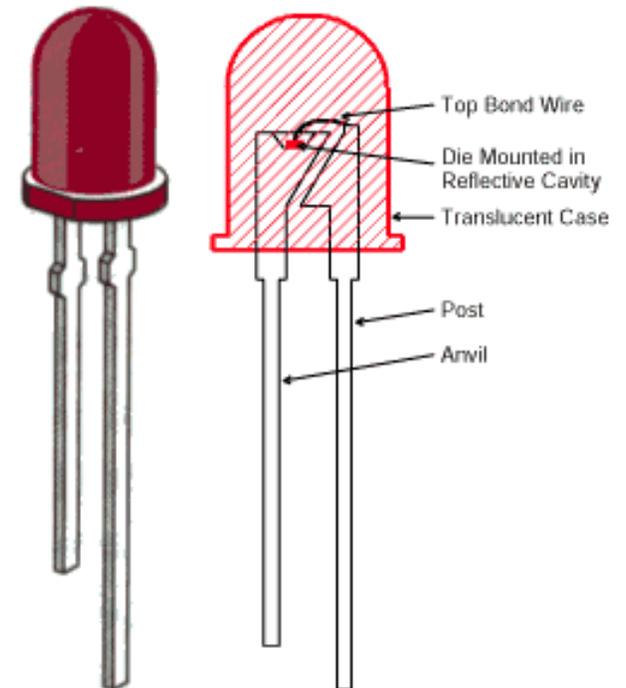
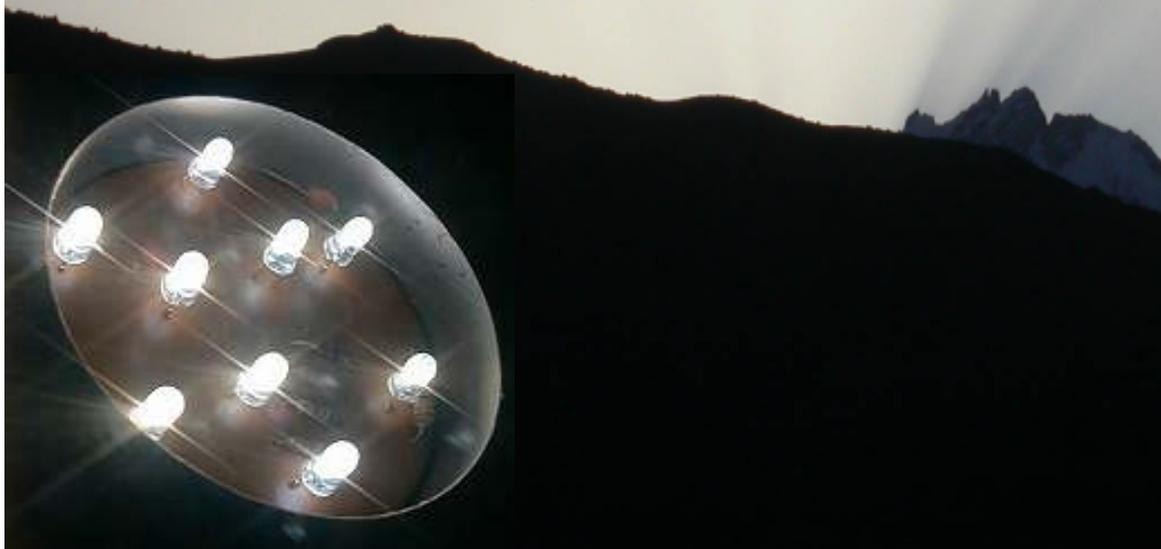
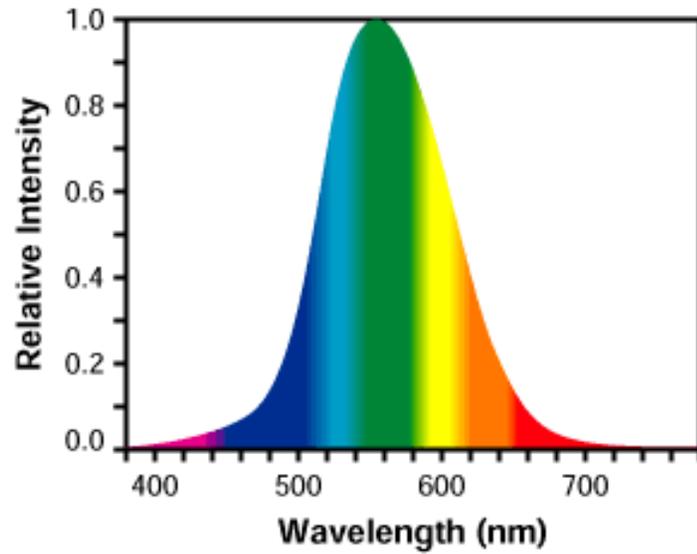
Each of the 63 homes
has 3 WLED
Lights, thus
total 189 Lights

4 x 75 Watt BP275F Solar PV Modules
mounted on a village centrally located
2-axis self-tracking frame, on the roof
of the purpose built powerhouse,
with battery bank.

All powerhouse to cluster
and home wiring is under
the ground, thus save and
protected



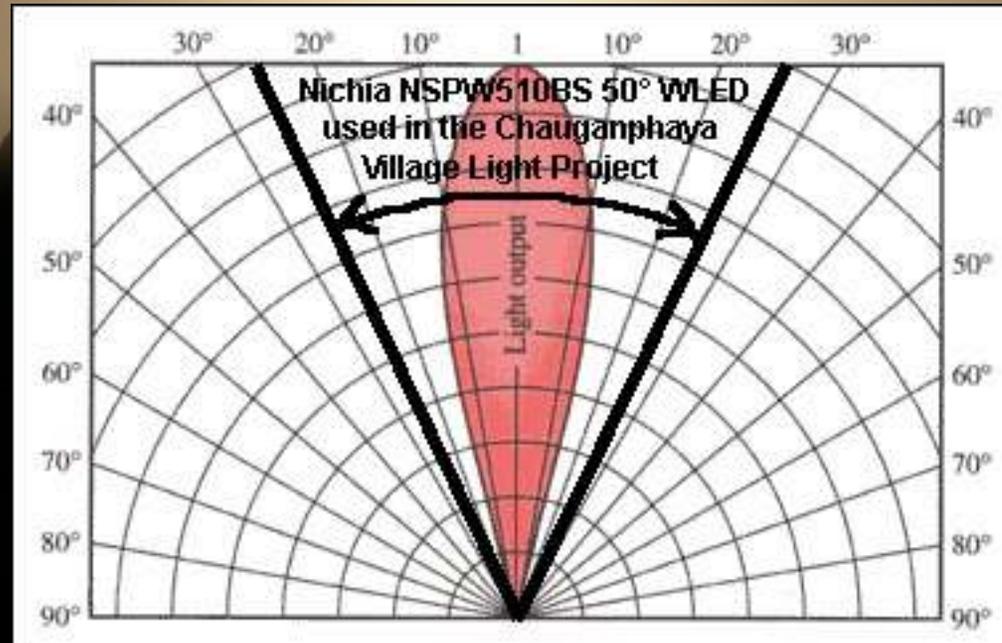
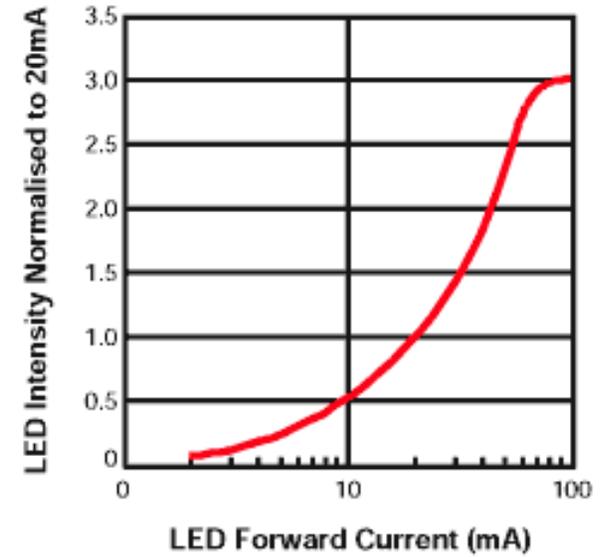
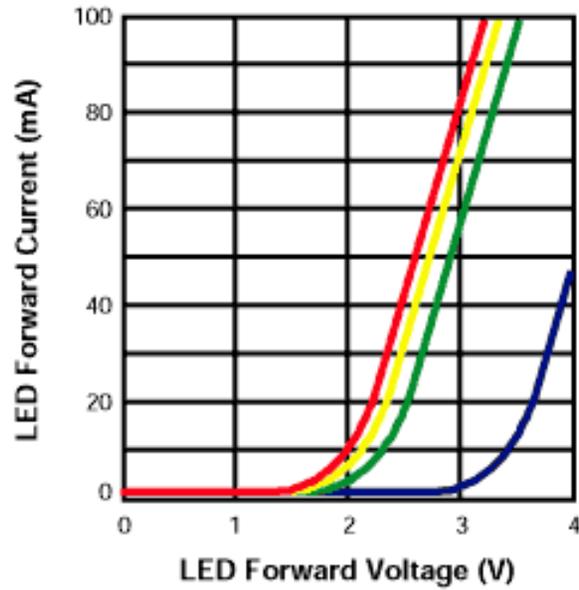
White Light Emitting Diode (WLED) Light



White Light Emitting Diode (WLED) Light



White Light Emitting Diode (WLED) Light



White

Light



Emitting

Diodes

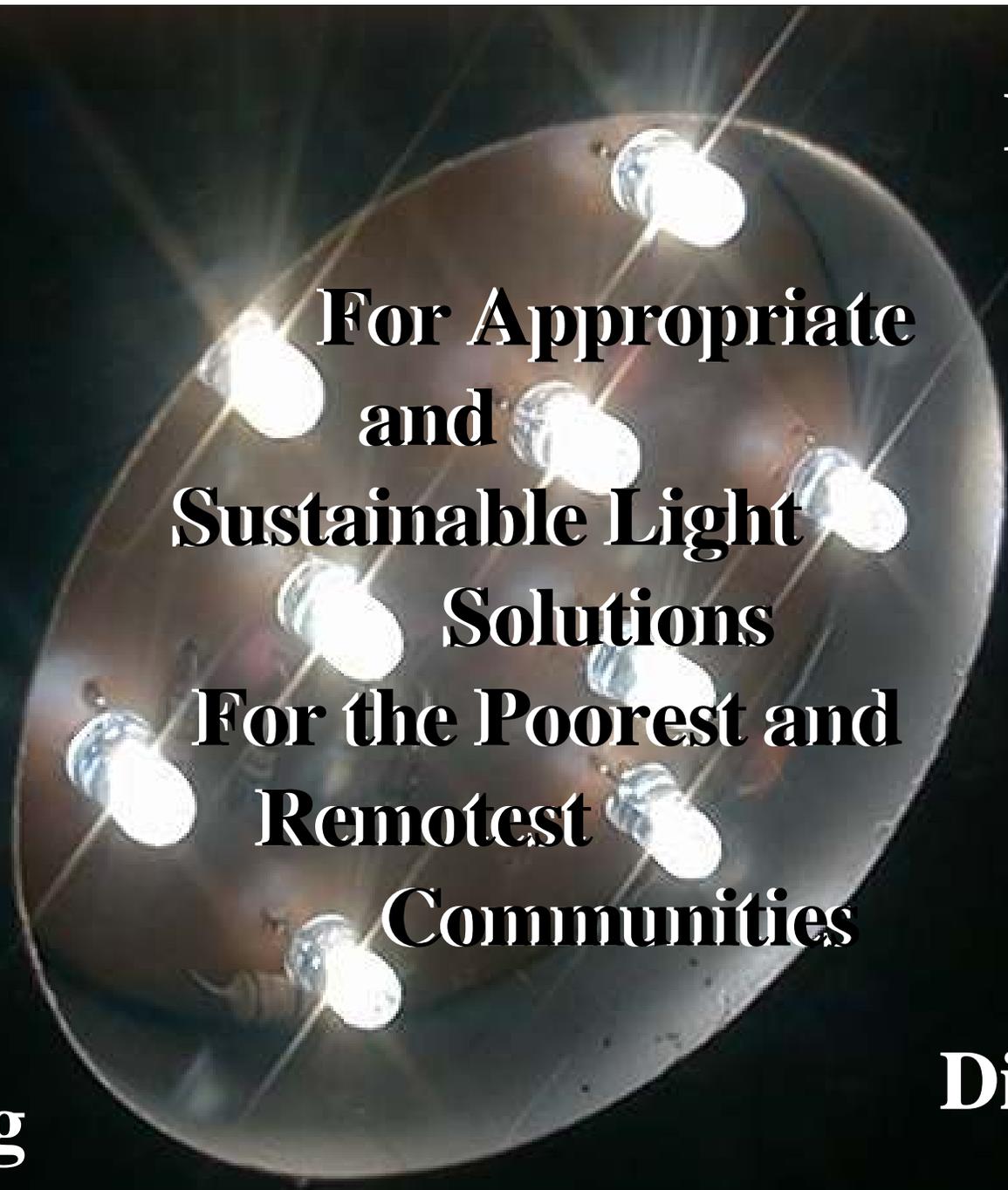
White

Light

**For Appropriate
and
Sustainable Light
Solutions
For the Poorest and
Remotest
Communities**

Emitting

Diodes





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